# Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

October 1955

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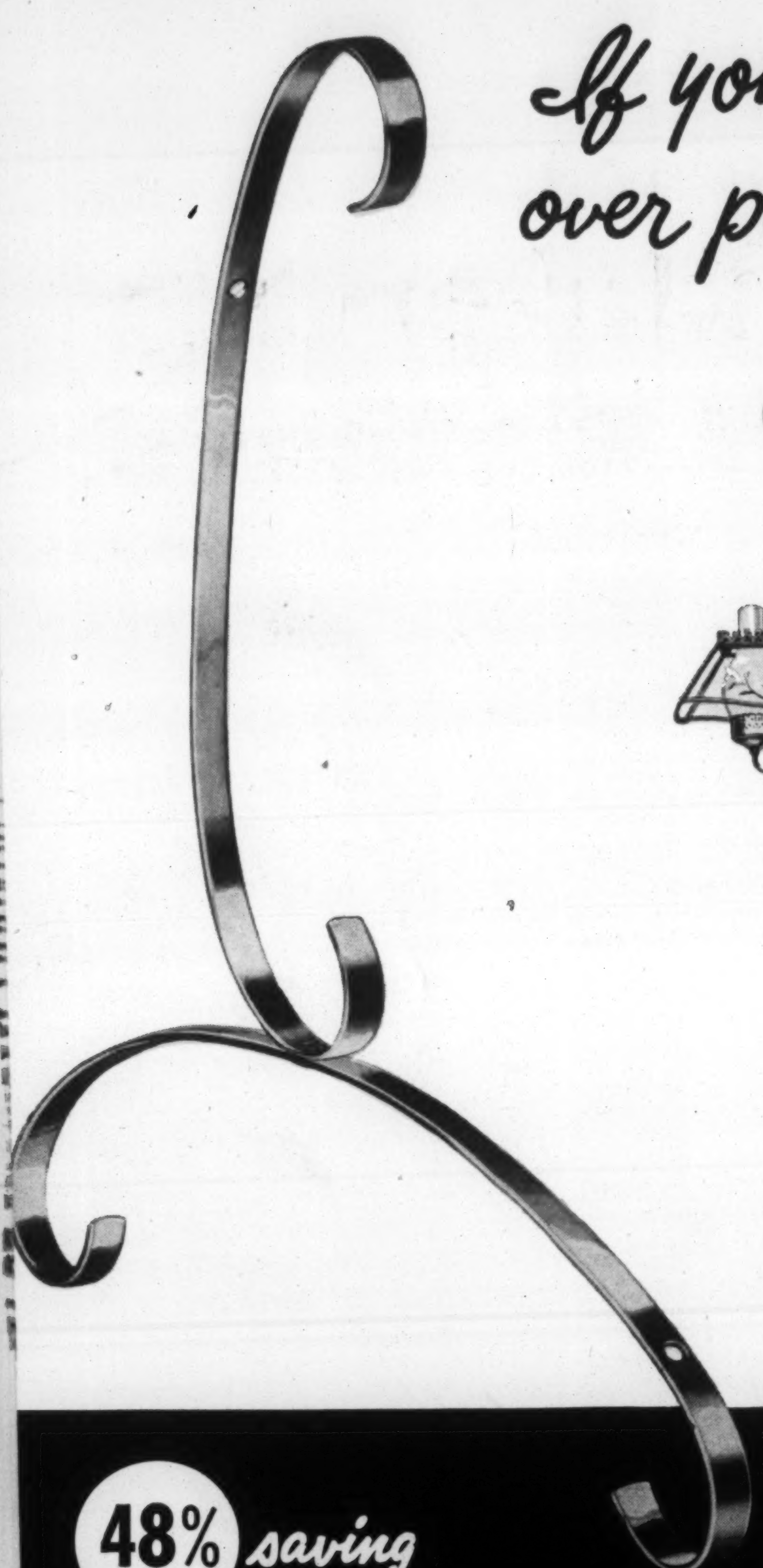
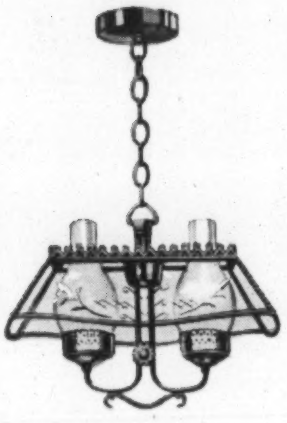
PRICE FIFTY CENTS

# *If you're eating your heart out over polishing costs---read this!*





Skyrocketing enthusiasm of America's homeowners for high-quality solid-brass lighting fixtures created a temporary bottleneck in the polishing room of Globe Lighting Products, Inc., one of the leaders in the field. This production problem coincided with the introduction of Formbrite* to the metalworking industry a couple of years ago.

Globe's acceptance of this easy-to-polish fine-grain drawing brass was immediate and enthusiastic. Results were highly successful from the very beginning. Work pile-ups in the polishing room were eliminated and polishing costs were cut in half on many items (see typical examples below). In addition, Globe learned, as have many others, that Formbrite provides a more lustrous finish—is harder, stronger, springier and more scratch-resistant, yet has remarkable ductility for forming and drawing operations.

Surprisingly, Formbrite doesn't cost a penny more than ordinary drawing brass. Why not pass the good news along to those who head up your engineering, design or production departments? Ask them to write for booklet B-39 . . . or phone for a sales representative . . . or request a free sample of Formbrite to try in your own shop. Address: The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

5580

*Reg. U. S. Pat. Off.

**For more information, Circle No. 328**

Parts illustrated are approximately three-quarters actual size.

**26%** ***saving*** Tens of thousands of these drawn canopies, socket cups, etc., have been made of time-and-cost-saving Formbrite.

**48%** ***saving*** 5/16 x .062″ round-edge Formbrite strip in this scroll eliminated a before-bending polishing operation.

**45%** ***saving*** After forming, this Formbrite channel edging is simply bright dipped, color buffed, degreased, lacquered. That's all!

**55%** ***saving*** This hard-to-handle ornamental banding now gets only a simple color buff, saving as much as the cost of the metal.

**Formbrite**

**FINE-GRAIN DRAWING BRASS**

**an ANACONDA product**

made by The American Brass Company

*Materials Engineering in Product Design + Manufacture*

# Materials & Methods®

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*Published monthly by*
**REINHOLD PUBLISHING CORP.**
*430 Park Avenue*
*New York 22, N. Y.*

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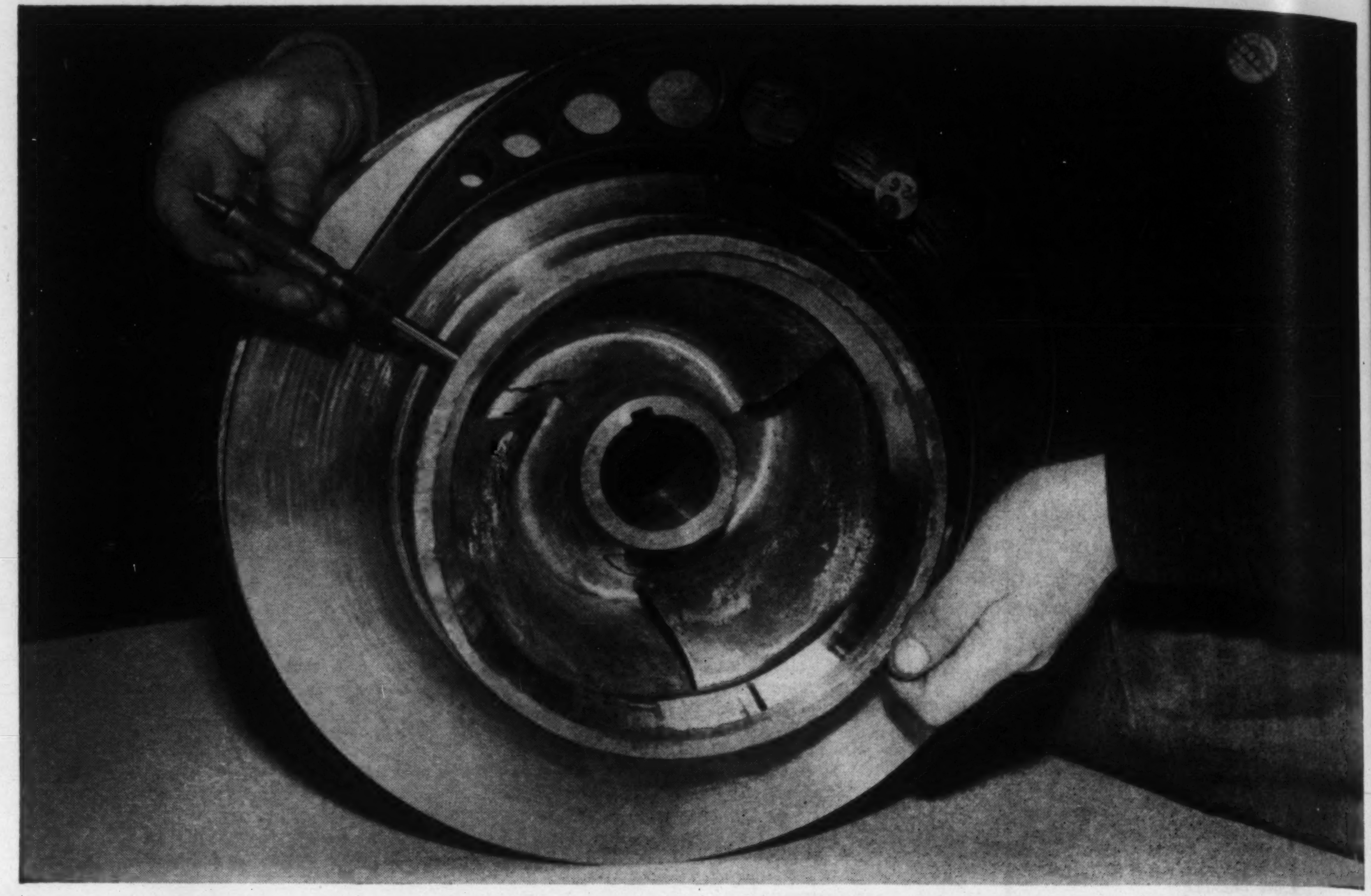


# Before Cavitation Strikes!

## A large pump manufacturer discovers a way to lengthen service life with Inco-Cast Monel

This Inco-Cast Monel impeller is getting a final check before being delivered to the Navy for shipboard use.

Aboard ship, the first-stage impeller of a centrifugal condensate pump wages a constant fight against cavitation-erosion.

### Cause of Cavitation Known

Pumps operate at about 28½ inches vacuum with low suction submergence at a temperature near boiling, forcing condensate into deaerating feed tanks against heads as high as 280 feet. Under these conditions, an impeller is subject to cavitation-erosion.

Sudden changes in ship's power change normal capacity and submergence . . . throwing the system into a severe cavitation-erosion condition. The near-boiling condensate erupts into steam, forming tiny bubbles. Flung at high speed with the condensate, these bubbles collapse against the first stage impeller resulting in impact shock pressures which scour the metal away and impose a water hammer effect on the sidewalls or shrouds.

As metal goes, down goes efficiency of the entire system.

### Cast Monel Proves Solution

Worthington Corporation finds that Inco-Cast Monel impellers last longer than bronze in this service. Besides standing up against erosion, Monel's greater strength resists bulging of the sidewalls, thereby preventing fatigue failure which sometimes occurs to shrouds of bronze impellers.

Because condensate pump impellers necessarily have large diameters, narrow waterways, thin shroud sections, and smooth spiraling vanes, Worthington has them cast by Inco.

They also find that with Cast Monel, the impeller (and hence system) efficiency stays high over a greater percentage of the life of the impeller. Thus Cast Monel provides *both* longer life and greater average efficiency.

### New Booklet Offered

Do you want to know more about how Inco-Cast Monel® resists cavitation and other destructive conditions? Then write for our new booklet, "Cast to Outlast."

**The International Nickel Company, Inc.**
67 Wall Street New York 5, N.Y.

INCO
TRADE MARK

**Inco Castings . . .** ***Sand, Centrifugal, Precision***

**For more information, turn to Reader Service Card, Circle No. 316**

# Materials Outlook

BETTER DIE CASTINGS can be obtained by a vacuum process already operating in England and now being licensed to the die casting industry in this country. Vacuum-cast parts have higher hardness and tensile strength than conventional die cast parts because of greater skin thickness and lower porosity. They are also more pressure-tight and have better surfaces. A process for zinc is now available, and cold chamber processes for aluminum and magnesium are being developed.

A NEW STYRENE PLASTIC has been developed. Called methyl styrene, it is tougher and withstands higher temperatures than polystyrene. Like polystyrene, it may be combined with acrylonitrile to provide still greater toughness. Plans for commercial production are being investigated, and no estimate of the eventual cost of the material has been announced.

ALUMINUM FOIL AND SHEET with an anodized film about 0.2 mils thick is being promoted by a major aluminum producer for spiral coil windings on transformers and some motors and generators. The integrally-insulated coils would be about half the weight of copper coils and might cost up to 50% less.

TWO CHROMIUM-MANGANESE-NICKEL STAINLESS STEELS designed to replace chromium-nickel alloys of the 300 series have now been assigned standard AISI designations. Types 201 (17 Cr, 4 Ni, 6 Mn) and 202 (18 Cr, 5 Ni, 8 Mn) are alternates for Types 301 and 302, respectively.

A FAIR PRICE FOR NATURAL CRUDE RUBBER would be no more than 23 cents a pound instead of the current level of 45 cents, according to a rubber industry executive. He blames current high prices on lack of restrictions on speculators, and predicts that continuation of the present methods of distribution will result in acceleration of "the complete changeover to man-made rubbers in the United States."

TWO OPPOSING TRENDS IN STEEL SELECTION can be observed in different segments of the automotive industry today. One company is concentrating on low-carbon steels, hardening them by through carburization after forming. Purpose is to minimize investment in heavy presses. Another company is concentrating on improved processes for forming medium-carbon and even alloy steels.

A NEW ZINC ALLOY IS SUITABLE FOR FLUXLESS SOLDERING or welding of aluminum and also has good dry bearing properties. Its melting point is about 600 F.

ANOTHER GRADE OF IRRADIATED POLYETHYLENE FILM has been developed particularly for encapsulation uses. Its tensile strength of

# Materials Outlook

4000-5000 psi is double that of earlier grades and it can be heat-shrunk rapidly above 260 F to provide a tightly-bonded, electrically insulating sheath.

IN-PLANT PERMANENT MOLD CASTING is being adopted by a number of manufacturers who wish to reduce inventories. Commercial availability of an automatic gravity casting machine that requires less than 100 sq ft of working space makes the captive operation feasible.

SOUND URANIUM AND URANIUM ALLOY INGOTS have been successfully cast by arc-melting raw as-reduced uranium with a consumable electrode. The process makes possible larger diameter ingots than vacuum induction melting.

ABRASION RESISTANCE OF RAYON CLOTH has been stepped up four times by applying a thin coating of synthetic rubber to the reverse side. The coating does not dull colors and the cloth remains porous. The coating also increases seam strength and prevents edge ravelling.

A NEW KIND OF METAL-POLISHING WHEEL is claimed to eliminate the need for fine grit set-up wheels, buffs or brushes. Consisting of hundreds of pieces of cloth coated with alumina or silicon carbide grits and mounted radially, the wheel has long life and maintains the same finish and rate of cut until it is worn down to the hub.

POLYURETHANE MAGNET WIRE COATINGS not only have excellent dielectric properties and high moisture resistance, but also are more easily soldered than conventional "solderable" wire, according to an isocyanate supplier.

CRACKING OF CERAMICS during formation of hermetic seals may be eliminated by replacing metal rod with thin-wall tubing. One manufacturer has found that although the metal in each case was selected to match the thermal expansion of the ceramic, tubing, unlike rod, could yield enough to absorb stresses resulting from unavoidable slight differences in expansion.

FORGINGS WITH BETTER MACHINABILITY are being obtained by some manufacturers through use of special leaded steels. Lead additions of 0.15-0.35% improve machinability about as much as sulfur contents of 0.08-0.13% but, unlike sulfur, do not tend to cause "hot shortness" during forging. Leaded mild, 4140 and 8620 steels are commercially available.

SILICONE-TREATED GLASSWARE is now on the market. A lubricating film on the outside of a bottle reduces breakage in handling, and an inside film makes contents more readily removable and reusable bottles more easily cleaned.

## Materials BRIEFS

**More Castings**
A survey of the members of the Investment Castings Institute indicates that investment castings sales for 1955 will be up 60.7% over 1954.

**AEC Information**
The Department of Commerce is stepping up release of large quantities of AEC technical data. First step was release of 961 research reports compiled by AEC scientists and engineers.

**Polyester Sculpture**
An adventurous sculptress has adopted glass reinforced polyester resin as a medium for her statuary. She claims the medium is easier to work, is lighter, and offers a greater range of texture and color.

**Steel Tire Cord**
Three hundred thousand mile truck and bus tires will be on the market soon as a result of success with a brass-plated, high-tensile, steel wire developed to replace standard cord.

**New High**
Germanium transistors have attained a new high frequency performance record. Latest experimental tetrode transistors operate at 1000 megacycles, well up in the UHF range.

**Growth Stopper**
AEC metallurgists have developed a method for preventing uranium growth during nuclear power reactions. Under some conditions, uranium rods have been known to double in length after burnup of 1 atom in 1000.

**Backwards**
The price of secondary aluminum (ingots from remelted scrap) has for some time been higher than the price of primary aluminum. Die casters tend to blame government stockpiling, since stockpiling requires primary metal only.

225° F.

*Now!*

**HARD RUBBER PARTS FOR HIGH TEMPERATURES**

**. . . ace tempron®**

Ace Tempron, a new synthetic hard rubber, now makes the chemical resistance, strength, and economy of hard rubber available for high-temperature applications! It is stable and rigid up to 225 deg. F. and higher, and shows remarkable resistance to many chemicals when tested at 200 deg. F.

Based on nitrile synthetic rubber (Buna-N), Tempron is available in three forms: (1) Molded parts, (2) sheet, rod and tubes, for machining a wide variety of shapes; and, (3) a hand-fabricating process for making tanks, large fittings, etc., by forming sheets of Tempron around cores or mandrels prior to vulcanization. Standard pipe and fittings are also made.

The table below tells the story – high tensile on a par with the better plastics – a chance to save weight – good impact strength – good dielectric properties – excellent chemical, oil and moisture resistance – and ability to withstand high temperatures without loss of mechanical strength.

*Let your imagination loose on these typical applications:* molded parts for hot jobs; special fittings for corrosives; transformer insulation; brine and gasoline meter parts; trays for vacuum dryers; plating barrels; hot brine systems; tubing for electrical condensers, magneto parts.

Do you make anything that might be improved by Ace Tempron? Why not look into it? Let us know and we'll be glad to help. No obligation, of course.

PHYSICAL AND ELECTRICAL PROPERTIES OF TEMPRON

| PROPERTIES | MOLDED PARTS, SHEET, ROD & TUBES | HAND-BUILT PRODUCTS |
|---|---|---|
| Tensile Str., psi. | 7170 | 7500 |
| Elongation, % | 2.70 | 2.80 |
| Specific Gravity | 1.24 | 1.25 |
| Hardness—Durometer D | 87 | 87 |
| Impact, ft.—lbs./in. | 0.41 | 0.49 |
| Flexural Str., psi. | 11,300 | 11,800 |
| Dielectric Str., v/mil, 60 cyc. | 400 | 460 |
| Power Factor, 1 kc. | 0.016 | 0.016 |
| Dielectric Constant, 1 kc. | 3.50 | 3.70 |
| Water Absorption, (48 hrs. R.T.%) | 0.12 | — |
| Heat Distortion Temp., deg. F. | 275 | 260 |

**ACE® rubber and plastic products**

**AMERICAN HARD RUBBER COMPANY**
**93 WORTH STREET • NEW YORK 13, N. Y.**

For more information, turn to Reader Service Card, Circle No. 363

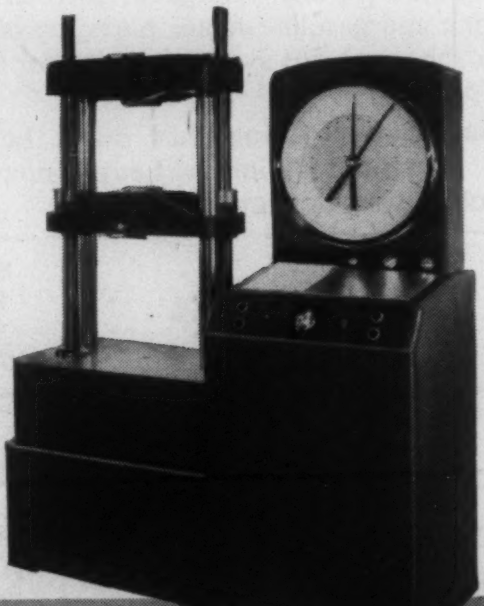
# This test may expose a "has been" in your testing lab

Are your machines adequate for present-day testing procedures? Or do they perform just well enough to get by? Often, testing machines in daily use appear to be doing the job . . . yet by today's standards are limited in versatility, convenience and accuracy.

Now may be the time to question whether you are getting as *complete* a test as you could with up-to-date equipment. Simply ask these 13 questions about your machines. It will take only a few minutes and may reveal whether your machines are really adequate . . . or outmoded and obsolete.

4 or more "no" answers probably mean you are not accomplishing as much as you could with new testing machines. And in that case it will pay you to return the coupon. Just check the "no" answers by number. A Riehle engineer will be glad to discuss specifically how Riehle equipment can make your testing more accurate and more convenient.

Mail the coupon even though you may not actually be in the market at this time.



60,000 pound Riehle Universal Hydraulic Testing Machine

## ADEQUACY TEST

1. Does my present equipment have infinitely variable speed control?
2. Can it control rate of loading?
3. Can it control rate of strain?
4. Can it hold a stress or strain in the elastic range indefinitely?
5. Can it utilize automatic load holding attachments?
6. Is its drive smooth enough not to affect the indicating system?
7. Can it obtain high magnification stress-strain recordings?
8. Does it have unlimited testing stroke over the complete distance between upper crosshead and weighing table?
9. Can it handle off-center loads?
10. Can it *un*load as accurately as it loads?
11. Does it have simple controls?
12. Is its accuracy independent of the operator's skill?
13. Am I proud of the appearance of my testing equipment?

*"One test is worth a thousand expert opinions"*

**Would you like to have a wall plaque bearing this famous axiom? The plaque is simulated bronze, suitable for hanging in your lab. There's no charge or obligation; just write for it.**

*Mail Coupon Today*

**Riehle** **TESTING MACHINES**

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Give me full details on what could be accomplished wit up-to-date equipment.

(Check numbers of questions answered "no.")

1 ☐, 2 ☐, 3 ☐, 4 ☐, 5 ☐, 6 ☐, 7 ☐, 8 ☐, 9
10 ☐, 11 ☐, 12 ☐, 13 ☐

☐ Send free plaque.

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# Men of Materials...

**Boyd M. Johnson,** General Manager of the Refractories Division of Carborundum Co. has worked with refractory materials for more than 25 years. He joined Carborundum soon after his graduation as a mechanical engineer from the University of Pennsylvania, and has, in the course of his career, held engineering, sales, and management positions in the company. He is a member of the American Ceramic Society, the ASME and New Jersey Society of Professional Engineers.

*Johnson says:*

## "Refractory materials meet needs for more precision, special properties . ."

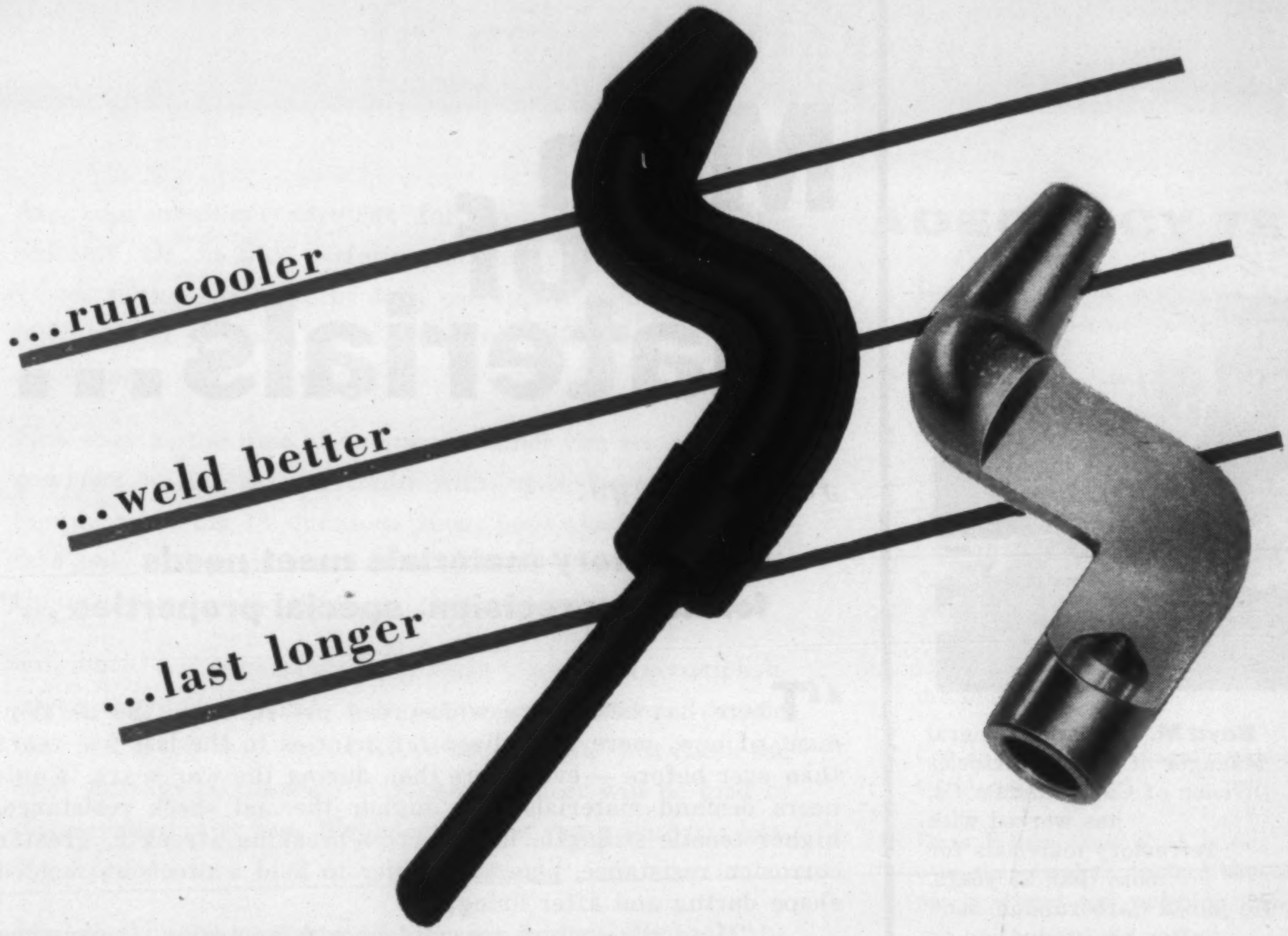
"There has been more widespread pressure for the development of new, more specialized refractories in the last five years than ever before — even more than during the war years. Engineers demand materials with higher thermal shock resistance, higher tensile strength, higher cross-breaking strength, greater corrosion resistance, plus the ability to hold a precision molded shape during and after firing.

"Materials—which we call 'super refractories'—have come along unusually fast to meet new requirements. For the materials producer, this has meant almost a new way of life. Processes and techniques that would have been outside the area of the ceramist a few years ago have been incorporated in producing refractory forms. Induction heating, hot forming, and atmospheric control are adding to the range of products now available in refractory materials.

"As a result of constant pressure and accelerated development, parts that would have been absurd by older standards are now in production. Threaded burner nozzles that screw on to fuel pipes; rotating pump impellers that operate at liquid metal temperatures; and acid spray nozzles that withstand high processing temperatures under extreme conditions of corrosion are a few of the industrial products now available in the highest temperature refractory materials.

"More and more, product designers and engineers are expecting metallic properties from refractories, and refractory qualities from metals. The metallurgists are approaching the problem from one direction, and the ceramists are making equal progress in adapting refractories. Intense pressure for new materials has made it necessary to put additional demands on developmental research, so that now research approaches a scheduled, production operation. Perhaps one of the best indicators of the industrial appetite for improved high temperature materials is that when a new high temperature material is turned up in the course of a research program, someone in industry will want it in quantity almost before we know whether or not we can produce it."

# MALLORY Cold-formed Electrodes



By means of special cold forming techniques, Mallory produces single-bend, double-bend and irregular shaped electrodes which have properties superior to those obtainable by conventional casting or hot forging.

**They run cooler**—because the cooling water tube goes closer to the tip. The tube can be bent in place*, and thus follows the shape of the electrode. The exclusive Mallory fluted cooling hole, which provides increased cooling area, can also be provided in these irregular electrode shapes.

**They weld better**—because cold forming develops strength and hardness considerably higher than that of cast or forged metals.

**They last longer**—because the combination of cooler operation and higher strength add up to longer runs between dressing . . . lower cost per weld.

Scores of "special" shapes can be produced promptly and at economical cost from Mallory's standard tools. You will probably find the exact style your application needs, in the Mallory series. For technical data, or for a consultation on your welding problems, call your local Mallory Welding Distributor . . . or write to Mallory today.

*Expect more . . . Get more from*

P. R. MALLORY & CO. Inc.
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P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

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**Electromechanical**—Resistors • Switches • Television Tuners • Vibrators
**Electrochemical**—Capacitors • Rectifiers • Mercury Batteries
**Metallurgical**—Contacts • Special Metals and Ceramics • Welding Materials

*Patent No. 2,489,993

For more information, turn to Reader Service Card, Circle No. 318

# MATERIALS ENGINEERING News Digest

## Copper's Status Threatened by Continued Shortage

As copper prices continued to spiral upward in September, the outlook for the copper industry appeared to be one of chronic illness. With consumer inventories steadily shrinking, and prices at record post-war highs, the prognosis for more stable market conditions became less and less favorable for the short term, and the possibility of return to lower price levels and adequate supply stretched farther into the future.

Current or even higher copper prices for the short term future seem inevitable. In mid-September, scrap refiners were finding few opportunities to buy high quality scrap at 41½¢ per lb. Such a scrap price is equivalent to a refined copper price of 46 to 47¢—and that copper won't be available until late November or December. With U. S. domestic copper prices at 43¢, some custom smelters were getting as much as 50¢ per lb for spot delivery, and imported copper was finding takers at 53¢.

United States copper prices are extremely dependent on foreign sources, since it is impossible to supply this country's needs from domestic mines. And foreign sources for the past two years have been anything but dependable. In Chili, politically inspired strikes and governmental manipulation of the exchange rate and copper allocations have almost totally upset Chilean sources of supply.

The Rhodesian group of mines, a significant factor in world copper supplies, abandoned in September their policy of fixed prices over a stated period. The group had previously guaranteed prices for thirty days, after which an adjustment could be made that was fixed for another thirty days. That policy went out the window on September 5 when prices for Rhodesian copper were set for 45¢ per lb, subject to change within 24 hr. This price was considerably below the London Metal Market price of 50¢ per lb for copper futures and current immediate-delivery prices of slightly under 50¢. So even higher Rhodesian prices are probable soon.

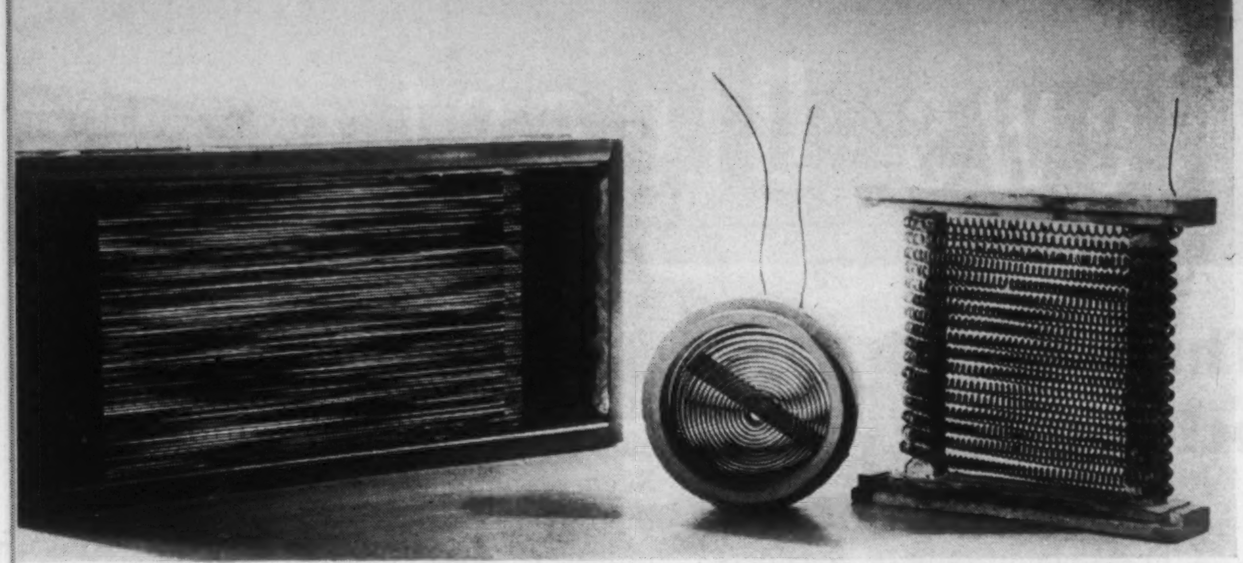
The U. S. Government seems to be doing all that it can under present law to ensure an adequate supply of copper. Eleven thousand tons of copper slated for the strategic materials stockpile in the fourth quarter have been diverted to industry, but copper men are far from satisfied. Three of the most powerful groups in the industry—the Copper and Brass Warehouse Assn., the Copper and Brass Research Assn. and the Wire and Cable Section of NEMA called on President Eisenhower to release 100,000 tons of copper bought from the Chilean Government last spring and now stockpiled. However, it appears that a special law will have to be passed which would require a special session of Congress if the stockpiled material is to be released. This is hardly likely unless the figure of 860,000 unemployed, a possibility that the report to the President threatened, becomes an actuality.

Copper suppliers, although receiving record prices for their product, are anything but happy about it. They realize that they can survive short term high prices—all the copper available is snapped up at any price now—but when the short term ceases to be short and the outlook for better price structure is as poor as it is today, their customers start spending money on research and tooling for substitute materials. Normally, no one will spend money to substitute aluminum for copper, for example, unless there is a better reason for the substitution than simply a roughly equivalent product. But when prices, and above all, supply, begin to look black for more than a short time, out come the drawing boards. Such planning obviously shadows the future for the whole copper industry, since demand will remain high up to the time that substitutes are designed, tooled, and put in production. Then the supply-demand picture may reverse suddenly, with attendant painful readjustments.

Although the potential market for aluminum as a substitute for copper in the electrical industry is not large by the standards of the structural aluminum market, aluminum suppliers are not missing a trick in urging copper users to switch to electrical aluminum. Reynolds Metals, for example, rushed through announcements of a new insulation technique for aluminum transformer and coil windings. Aluminum coils so insulated are claimed to require no more space than copper for the same amount of capacity. Other traditional copper bailiwicks are endangered as well—bronze screening is getting a run from aluminum and glass-reinforced plastics, and automotive companies are being urged to consider aluminum wiring for automobiles.

Flooded mills in the Northeast are resuming production at a fast clip, but lack of material is already one of their worst problems.

It is unfortunate, in the face of a truly adequate world supply of copper, that constant labor disputes and internal and international political maneuvering are stretching a short term shortage into an interminable, unstable situation that is likely to drive many copper consumers out of the market. Only by immediate stabilization can the copper industry hope to avoid a readjustment that may see many of their best customers turn to other materials. And getting customers back is just as hard as landing them in the first place.



**Air filters** *of fine wire coated with a catalytic agent can burn smoke, odors, grease, and bacteria from any air stream passing through them.*

# Catalytic Filters for Home Appliances

Smaller versions of the catalytic air purifiers used in industrial stacks and engine exhaust systems have invaded the home appliance field. If they live up to their initial promise of providing smokeless, odorless cooking and air purification, they will win a permanent place among the features of stoves, ovens, space heaters, and perhaps air conditioners.

Behind the development of the new catalytic elements is a new process for applying very thin, heat resistant platinum base coatings to chrome-nickel wire or thin strip heating elements. Oxy-Catalyst, Inc., developers of the miniature air purifiers, see a wide market for their product. The first Oxycoils are already in mass production for one range manufacturer.

The catalytic action of the platinum coating, heated by the chromium nickel electrical element, will oxidize or burn almost all organic matter at temperatures below its normal combustion point. In the presence of the catalyst, combustion is so complete that hydrocarbons are reduced completely to water and carbon dioxide. Since all greases and most odorous gases are organic in chemical composition, the exhaust from the catalyst is odorless. In addition to ridding the air of grease vapor and odors, the catalyst also consumes any living bacteria that may be present, sterilizing the air in space heaters or sick room air circulators.

The new device, known as Oxycoil, resembles the heating grid of a toaster or electric heater. The first mass produced element, which will go into a household range, is only ¾ in. thick, 3½ in. wide and a little over 7 in. long. It is mounted at the end of the range oven exhaust duct. Connected to the electrical circuit of the oven burner, it goes into operation immediately when the oven is turned on. The catalytic element consists of 103 feet of 25 gage platinum coated heating element wrapped around porcelain end posts and housed in a stainless steel frame.

The development of a rugged, heat resistant platinum based compound to coat both wire and thin metallic strip led to the production of practical catalytic purifiers for both appliance and large industrial use, according to Oxy-Catalyst, Inc. For commercial applications, the catalyst coated wire can be wound on bobbins, formed into helical, spiral, or irregular shapes suitable for insertion into pollutant streams. Since the catalyst is not consumed by the chemical reaction, and the coating is self cleaning, the lifetime of the purifying element is quite long in most atmospheres. Testing programs indicate that such elements will have lifetimes at least as long as most home appliances.

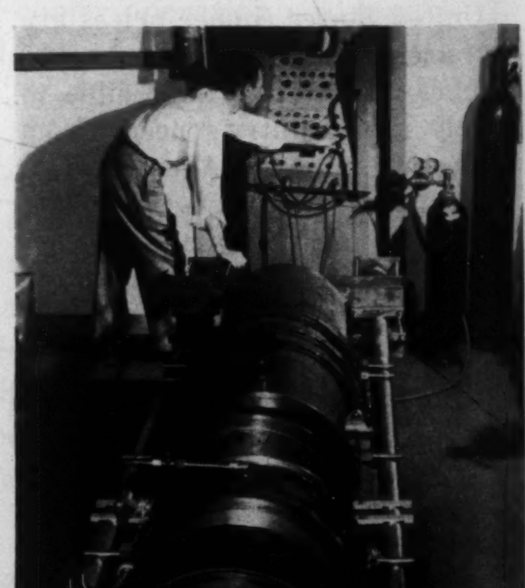
# NYU Develops Impact Tester

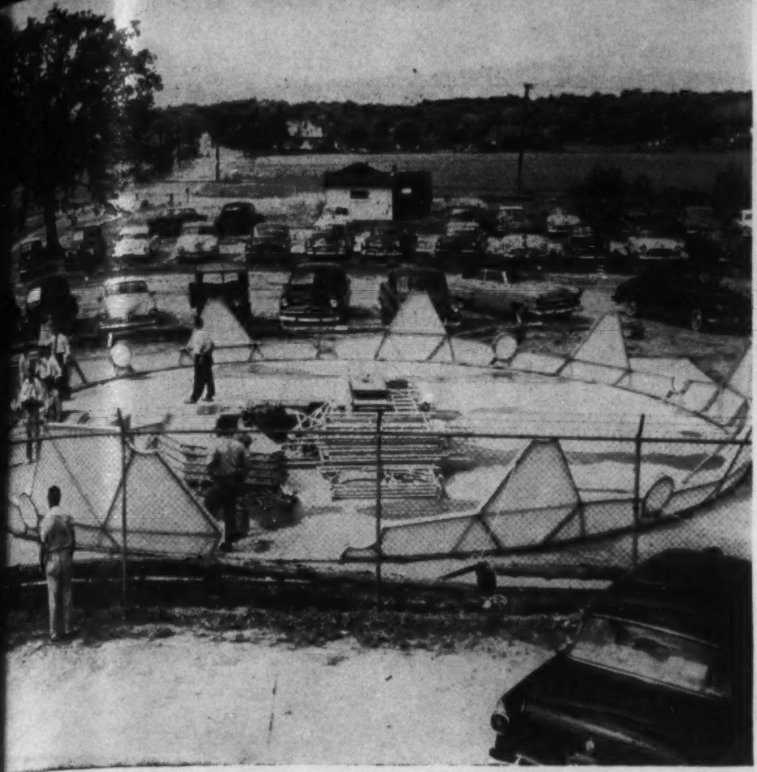
A new impact tester capable of describing impact in terms of dynamic stress-strain relationships has been developed by researchers of New York University College of Engineering. The testing instrument, called an impact tube, largely eliminates the variables caused by wave propagation due to sudden shock.

Knowledge gained through the use of the new impact tester is expected to help establish better design criteria for aircraft, press formed parts, and other materials subject to impact loads.

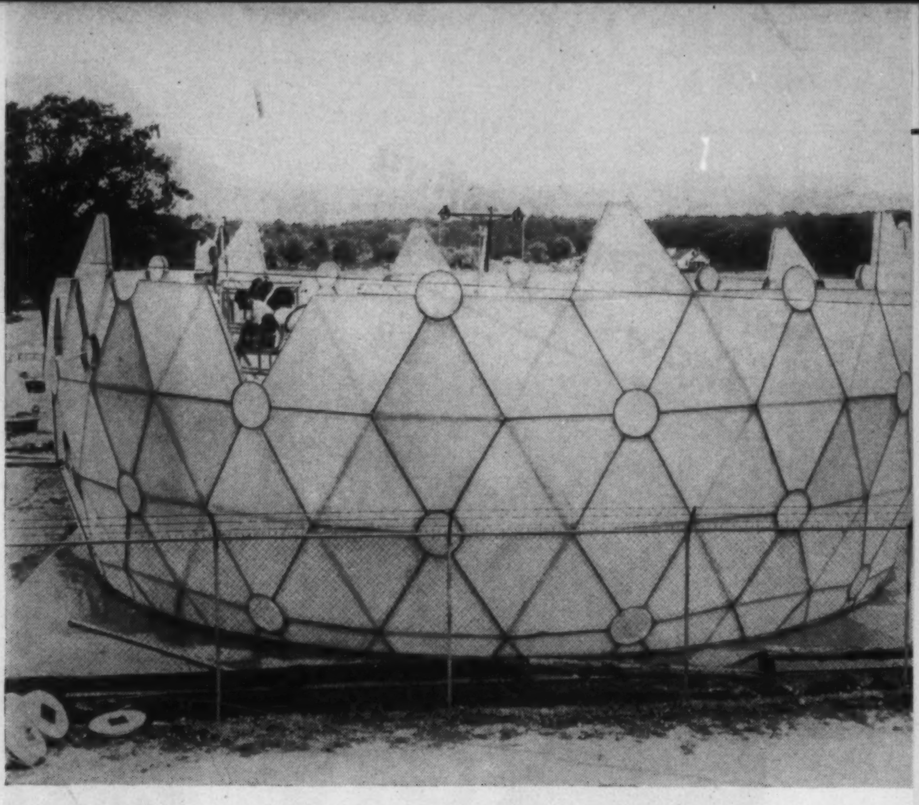
To date, the NYU Research division has had aluminum, steel and titanium alloys under investigation. Eventually, with improved impact testers and more facilities working on the problem, stress-strain relationships under sudden loads may be as common as static stress-strain data.

The impact tube is able to separate stress-strain relationships from wave propagation effects due to the extreme planarity of the shock wave produced in the tube. The effect of impact is measured over the entire face of the disc-shaped specimen.





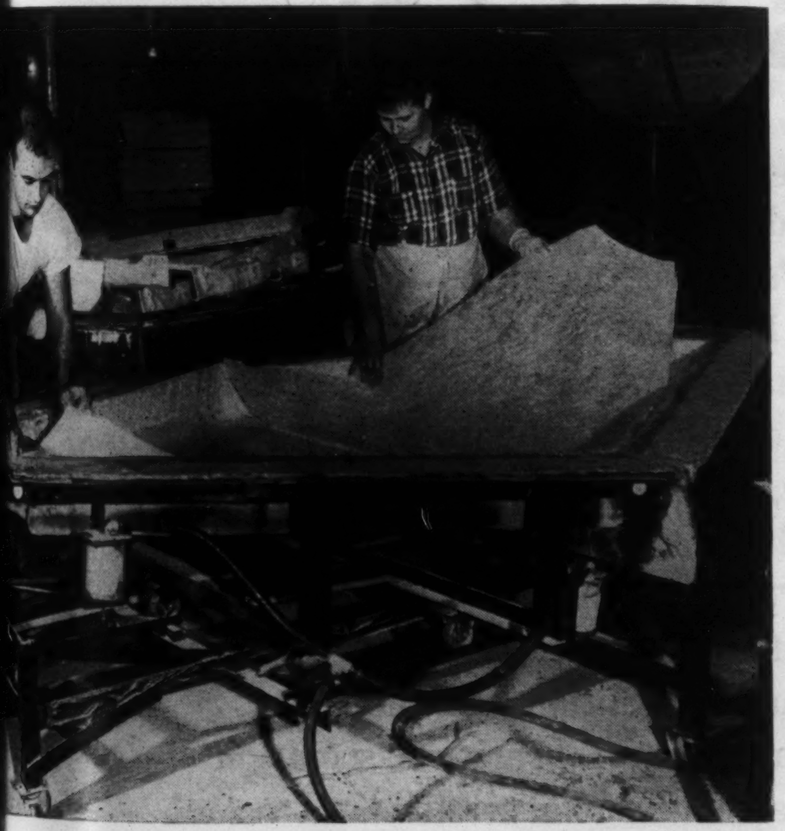
**me base** *bolted to mockup of radar installation platform.*



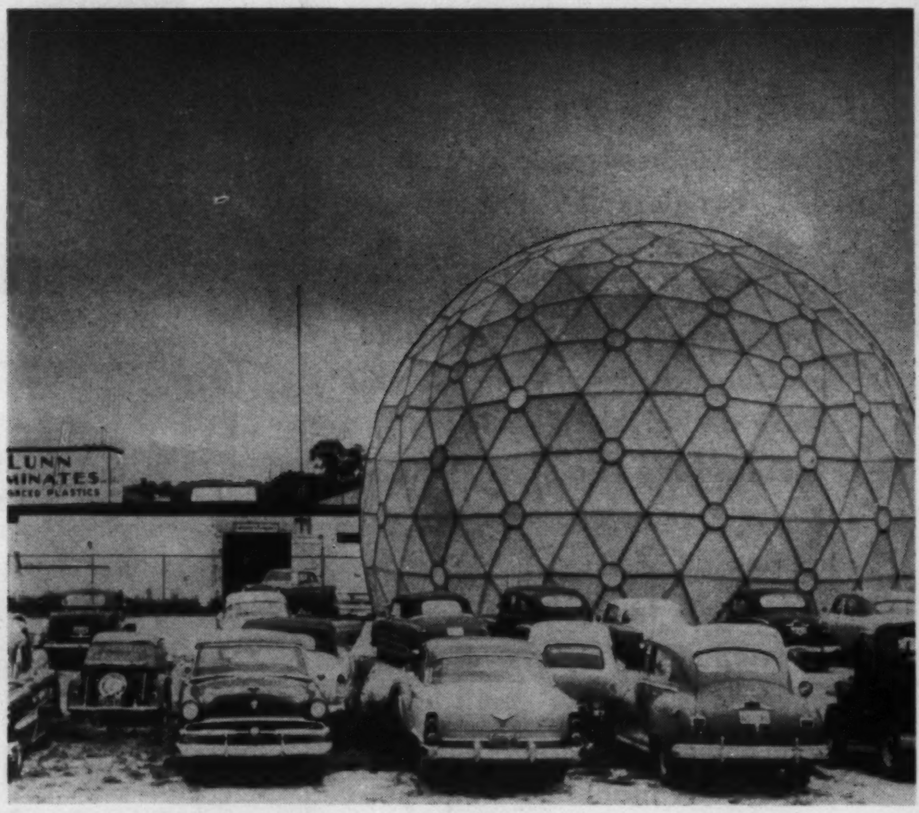
**Dome rises** *as triangular plastics sections are added.*

# Plastics Dome for Radar Net

*Fuller's Geodesic design resists winds to 200 mph.*



**me section** *is laminated fiber glass mat and polyester.*



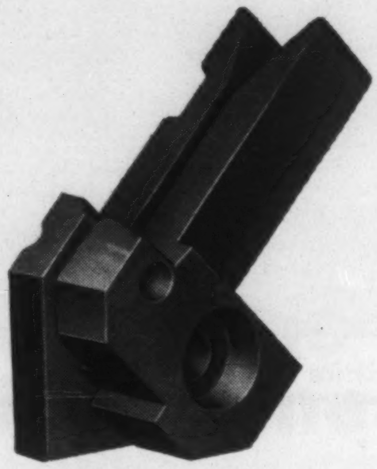
**Dome complete** *is air tight, yet transparent to radar.*

■ Looking much like a Gargantuan Japanese lantern, a large luminous dome adds a ghostly touch at nighttime to the quiet countryside near Huntington Station, L. I.

The dome is the first of a number of similar translucent plastic structures that will serve as tops for radar warning stations in the Arctic. Standing 40 ft high and 55 ft in diameter, the truncated sphere is the largest clear-span rigid plastics structure ever built. A Geodesics, Inc., design, its ma-

*(Continued on p. 236)*

**Investment Casting shows the way**



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# 1955 Metal Show

The 1955 Metal Show—the 37th National Metal Congress and Exposition—will take place in Philadelphia's Convention Halls September 17 through 21. In addition to the American Society for Metals sponsored Metal Congress, the American Welding Society will hold its National Fall Meeting, as will the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. Concurrently, the Society of Nondestructive Testing will hold its 15th Annual Convention, and the Metals Division of the Special Libraries Association will conduct an educational session.

The founder-sponsor of the Metal show, the American Society for Metals, has booked close to 500 metals and metalworking exhibitors for the Metal Exposition. For a condensed list of the technical subjects that will be covered in the Metal Congress Meetings, see page 17.

# One point of view

## *Another voice calls for basic research*

Many times in this space over the last few years we have sounded off about the need for more materials research. In most cases we have warned that the designs of our engineers cannot be achieved, in many instances, because of a lack of materials with the necessary physical and mechanical properties.

That situation still exists, of course, and probably will for a long time. The American Society for Testing Materials recognizes the problem and, at the same time, pictures still a different role for engineering materials. In a report prepared for the ASTM Committee on Research, Dr. H. H. Lester suggests that materials could and should inspire better designs.

In a manner of speaking, Dr. Lester is saying that research should be carried on to develop new materials for which no immediate uses are known. Assuming that the materials will have properties now lacking in available materials, he feels that these new developments will inspire engineers and other creative thinkers to greater inventions and applications of science.

Some companies already have brought out materials for which they can see no immediate commercial applications. Off-hand, I can think of perhaps a half-dozen instances. Actually, it is difficult to set out to develop a completely new material. Usually the new materials have been built to a set of specifications, although some have come as accidental discoveries made in the course of other research.

All of this again adds up to the fact that there is a growing demand for pure research which does not have to pay its way with immediate results. Perhaps some of the affluent companies which are now making substantial contributions to the educational funds of schools and colleges might be wise to insist that some of their money be devoted to fundamental research in the field of materials.

T. C. Du Mond

***This 1250-ton extrusion press*** *has extremely high speed and is capable of extruding 6-in. dia billets of super alloys.*

# GE Seeks Better Understanding of Materials in

*Scientists to study older materials, develop new ones, perfect fabricating techniques and investigate economies of materials applications in well equipped facility.*

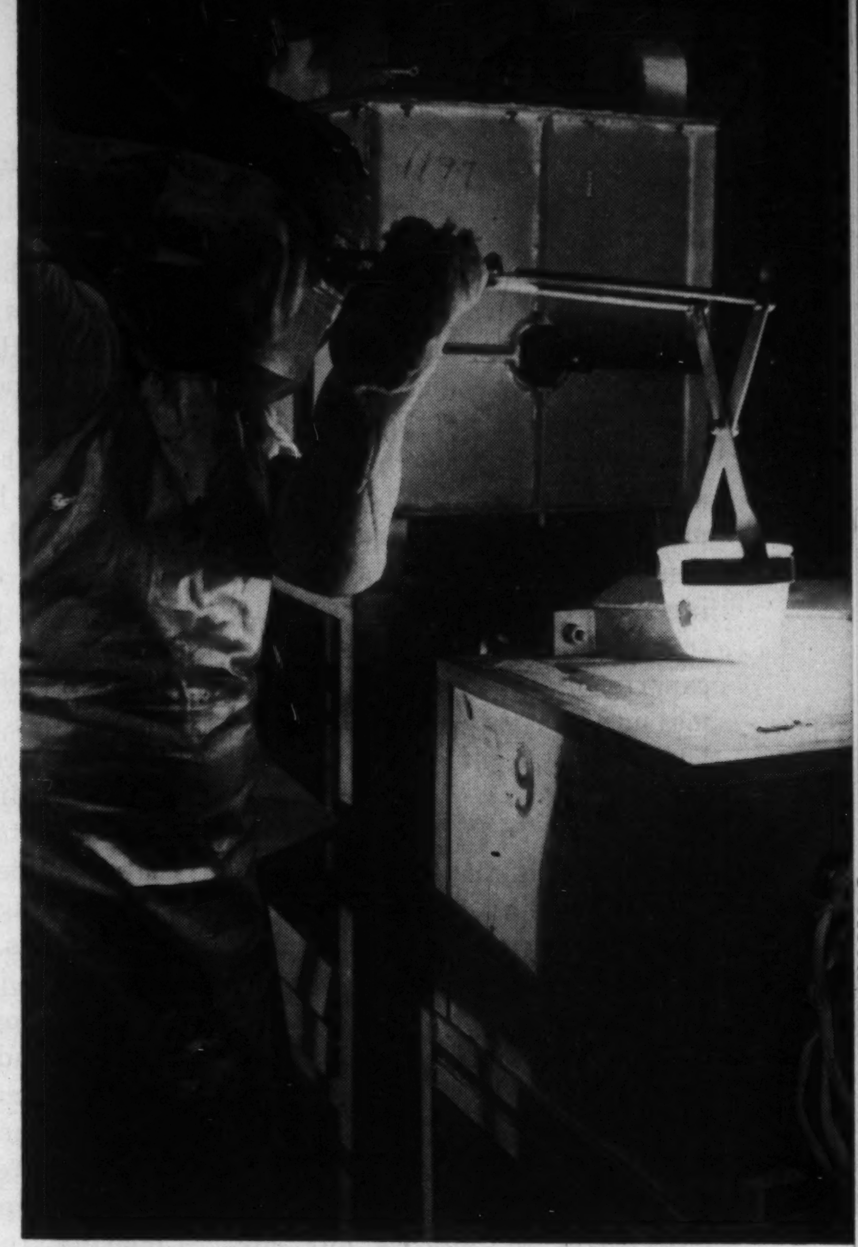
**by R. L. Fullman and R. M. Parke,** *General Electric Research Laboratory*

■ It has been said so often as to become an "old saw" that metallurgy and ceramics are old arts and young sciences. The usual implication is that metallic and ceramic materials on which today's technology and modern conveniences are based are the products of ancient crafts, as yet untouched by the results of a budding science of crystalline solids.

This interpretation has already lost much of its validity, as can be appreciated by making a fresh and realistic appraisal of the technical effort underlying the development of superior materials now available for many applications. The role of scientific research is particularly evident in those applications where materials have been the critical limiting factors in obtaining improved performance. It is natural that materials for these applications have received the largest share of the effort to apply our young science to obtain properties not realized by centuries of empirical development.

To some, perhaps, particularly to those closely allied with the growth of the science of crystalline solids, the relationships between that science and materials now in use will be difficult to perceive. The difficulty does not arise from an insufficient number of contributions of science to improved materials, but from the fact that materials now in use have benefited principally from the scientific understanding of a number of years ago. Few materials, indeed, already have benefited from those most recent re-

**A portion of the "Erector Set" balcony** *utilized in GE's new Metals and Ceramics Building. Thousands of bolt holes permit quick changes in building segments.*



**Laboratory worker removes a crucible** *with specimen from an electrically heated furnace in the ceramics area of the laboratory.*

# New Research Laboratory

search results that claim so much of the active scientist's attention that they become to him synonymous with the science.

**Reducing "lead" time**

The paucity of contributions of nearly current science to the improvement of the properties of metals and ceramics is a symptom of the long "lead" time required for translating new knowledge to new or improved products. This lead time is a serious barrier to full utilization of the scientific understanding now available to us.

One of the principal purposes of the new Metals and Ceramics Building at the General Electric Research Laboratory is to help its scientists translate new knowledge into new and improved processes and materials much more surely and swiftly than ever before possible. This new building houses equipment for processing metals and ceramics on a scale that would suggest a factory, rather than a laboratory. But closer inspection will reveal that the Metals and Ceramics Building is no ordinary materials factory, but a "know-how" factory. In addition to the most modern equipment for the processing of materials, it contains laboratories for small scale evaluation of new processes and materials. The results of these studies will indicate which developments should be "scaled up" to permit more accurate evaluation of their technical and economic feasibility. An area approximately equal to the laboratories is devoted to offices, where blackboard and scratch pad are the most important items of equipment.

In order to permit pilot operations to be set up, evaluated, and dismantled when the "know-how" has been extracted from them, a portion of the internal structure of the building is like a giant "erector set." Thousands of bolting holes, aligned throughout the building, permit quick assembly and easy alteration as a process is developed and perfected, and equally easy disassembly when the pilot plant has served its purpose. Services available on a "turn the handle" basis include compressed air, high and low pressure steam, city gas, nitrogen, oxygen, standard hydrogen, dried hydrogen (−130 F dew point), rough vacuum, distilled water, cooling water, and hot and cold tap water. Rapid chemical analyses required for controlling processes while they are in progress can be obtained in the building's analytical laboratory. Electrical and magnetic properties of experimental materials can be measured in its electrical testing laboratory.

### Understanding present materials

Facilities of the Metals and Ceramics Building will be used in a number of ways. Presently used materials will be studied in a search for improved understanding of the sources of their desirable properties. Knowledge gained in this manner will be combined with the best current information from basic science studies to devise means to improve our current ceramics and alloys, or to synthesize entirely new materials. The application of entirely new principles for the attainment of desirable property combinations will be thoroughly explored and the results will be critically evaluated. Similarly, new processes will be developed, based on knowledge acquired in the basic research work of the Research Laboratory and other laboratories throughout the world. The impact of new processes may be manifested in improved properties of familiar materials, or by enabling the production of new materials that could not be prepared satisfactorily by conventional processes.

Processing equipment available in the Metals and Ceramics Building includes extensive equipment for melting and casting of metals and alloys. Super-alloys for tomorrow's jets, rockets and other new developments must be melted under conditions unattainable in normal commercial practice today. During melting, the alloys must be protected from reaction with the atmosphere. Accordingly, arc melting furnaces have been designed and built, capable of melting the most refractory metals under vacuum and in inert gas atmospheres. In one of the building's new furnaces, ingots of super-alloys weighing 300 lb can be produced at a rate of three a day. Advanced designs now being formulated may enable the furnace to produce, by a continuous process, an ingot weighing 4000 lb or more.

A smaller, 50-lb vacuum arc furnace will supply researchers with alloy samples for earlier stages of evaluation, and a number of similar laboratory-size furnaces will fill the needs of scientists requiring small quantities of many kinds of alloys for their investigations.

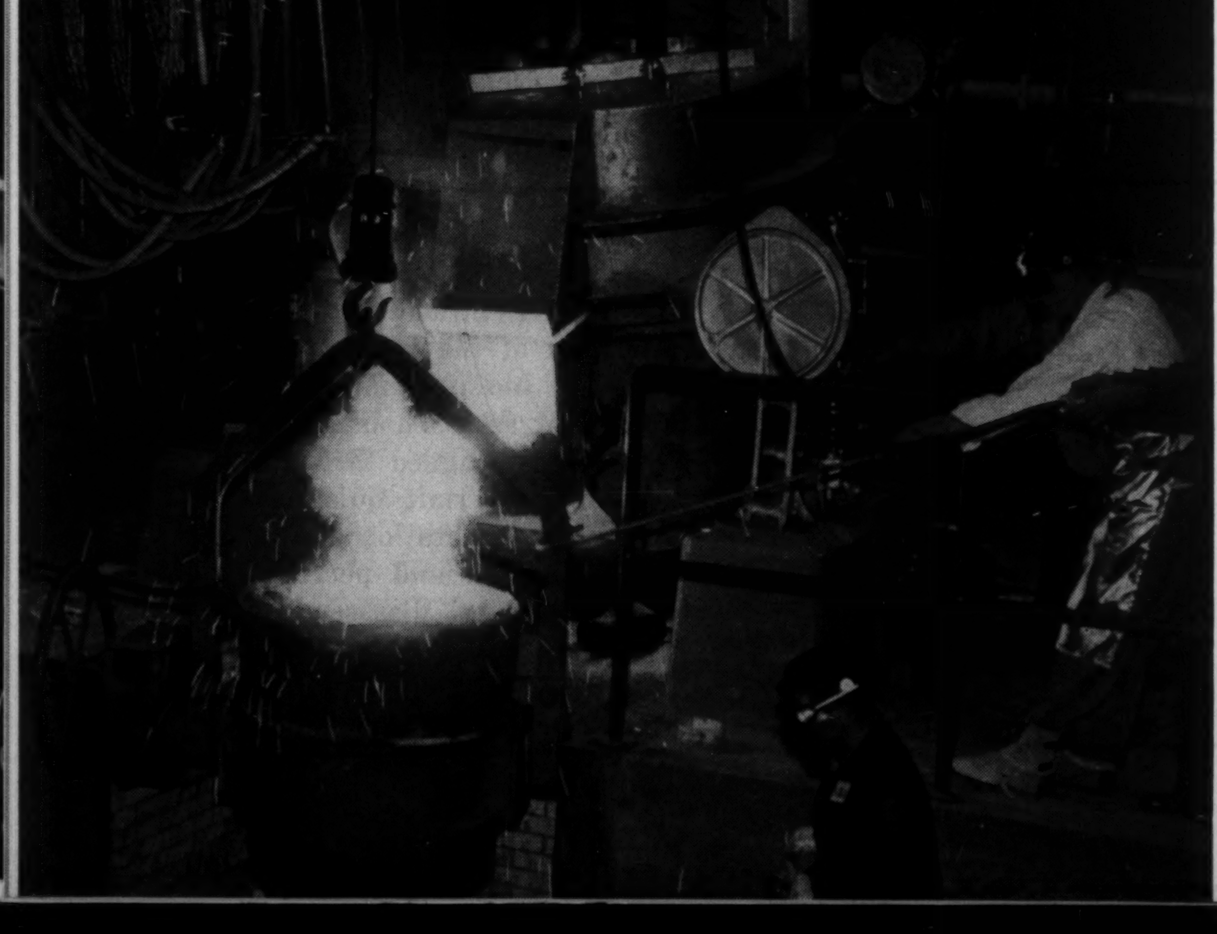
An industrial type, three-phase arc furnace has been installed for the preparation of one-ton heats of steel. Induction furnaces for melting metals and alloys in vacuum controlled atmospheres or air are also available in several sizes to supply the diverse needs of the Research Laboratory's various investigators.

Forming equipment available in the Metals and Ceramics Building includes a hydraulic extrusion press of 1250-ton capacity, specially designed for rapid extrusion of super-alloys. There is a 2500-lb drop hammer, a 250-lb and a 2500-lb forging hammer. In addition to swaging equipment, a new reversing two stand rod-rolling mill has been installed. The rod mill has been specially designed for high speed operation, to permit super-alloys to be formed to final size before they cool significantly from the annealing temperature.

A Sendzimir cold mill for rolling metal foils to thicknesses less than a thousandth of an inch is enclosed in a separate room where it is protected from dust particles which might destroy the quality of extremely thin sheet, if ground in during rolling.

A Sendzimir planetary hot mill, one of the first of this novel equipment for working metals, is available for rolling slabs and ingots. This mill will, in one pass, reduce a 1⅛-in. thick slab to ⅛-in. strip and so effects a great lowering

***One-ton heats of steel*** *for research are produced in this industrial type basic electric furnace.*



of equipment cost while reducing the number of reheats during rolling.

Much of the equipment for metal processing will be used for melting, heating and shaping of ceramic materials. However, presses, furnaces and mixing equipment especially for ceramic processing have been installed in separate areas to avoid contamination. This isolation is very important in preparing ferrites, ferro-electrics and ceramics with specially controlled expansion characteristics.

Sometimes the development of new processes will, as was noted in the melting of refractory metals, require the design and construction of wholly new apparatus. In recognition of this need and the need for development of continuous operations involving established "unit" processes, a free space of 1000 sq ft has been set aside near the center of the building. Having served such a purpose, this "process development—equipment development" area will be cleared for the next experimental program.

## Using the facilities

It is appropriate to examine in greater detail just how the facilities provided in the new Metals and Ceramics Building will assist General Electric scientists in converting new scientific discoveries into new and improved products more effectively and more rapidly. One of the least explored fields of materials research is the influence of the "scale factor" on the processing and properties of materials. When a new material or process is "scaled up" from the normal laboratory-sized experiment to put it to commercial use, radical differences frequently are found in the properties of the materials or the operation of the process. These differences probably arise primarily from the impossibility of truly "scaling-up" all the significant features of the material or process. Suppose a forging 20 ft long and 4 ft in dia is made from a material previously evaluated in samples measured in terms of a few centimeters or millimeters. The grain size, particle size of dispersed phases, stress fields around dislocations and atom diameters are not similarly "scaled up." Suppose a process occupying 1000 sq ft of factory floor space is set up on the basis of information obtained on a laboratory bench. The heat transfer coefficients across interfaces, the ratio of surface to volume and other critical processing variables cannot be "scaled up" without considerably more understanding of the roles of these variables than is available from theory in many instances. Hence, successful and rapid transitions from laboratory to factory frequently require experimental examination of the influence of the scale of operation. Technical feasibility of a new process or material must be evaluated on a suitable scale—not necessarily a full production scale, but usually on a scale not conveniently attained in a conventional laboratory. Equally important is the evaluation of economic feasibility, and again the costs of an operation or material are not easily estimated from an experiment whose scale is too far removed from that required in production.

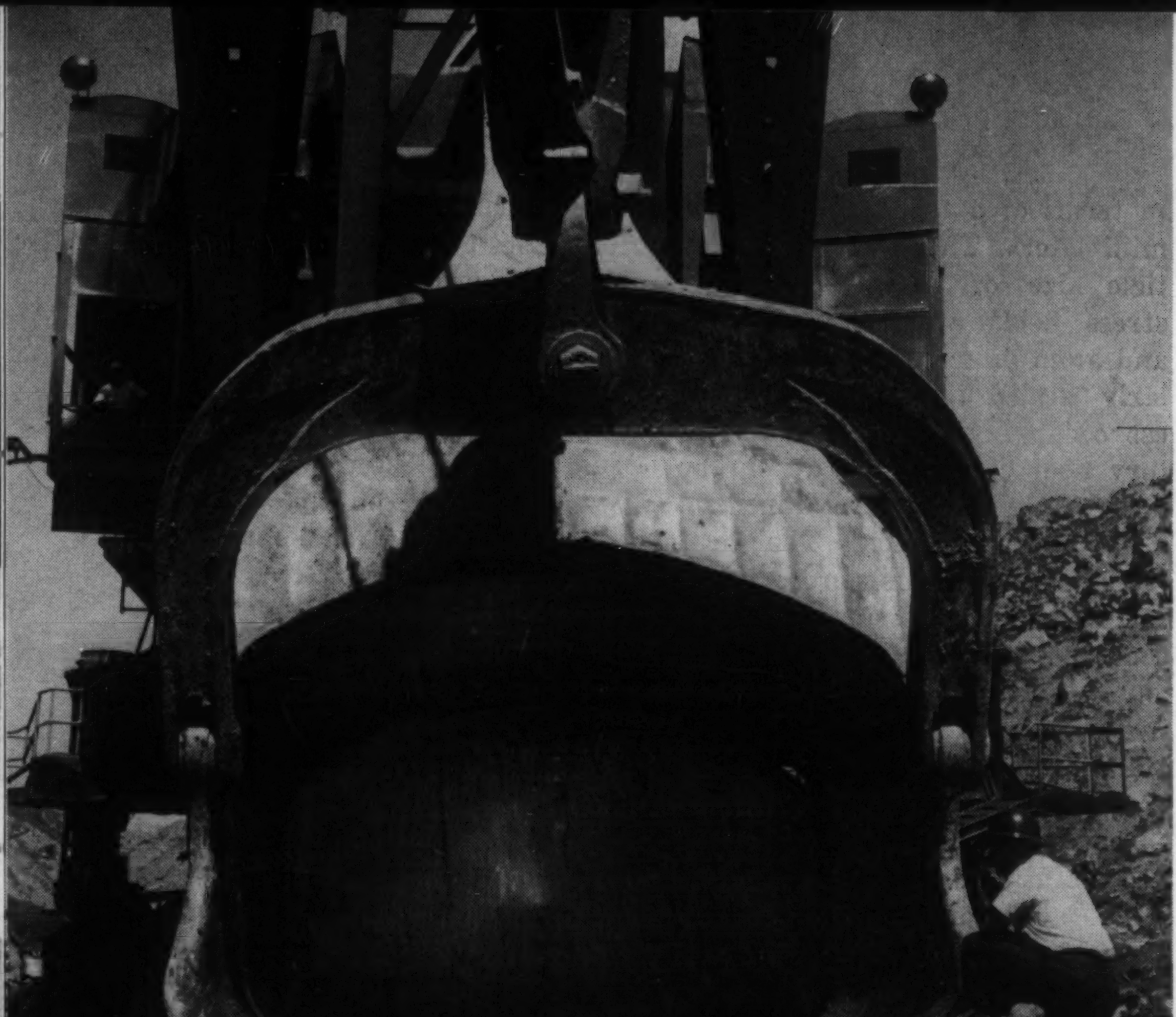
Experiments to evaluate technical and economic feasibility of new processes and materials, and to learn more about how the scale of operation influences the operation of processes and the properties of materials, are an essential requirement for effective and rapid conversion of new ideas and discoveries into useful products. These experiments can be carried out with maximum effectiveness only if suitable equipment can be made available without interfering with production. The facilities of the Metals and Ceramics Building provide unprecedented opportunities for conducting "scale factor" experiments without interfering with the manufacture of current materials and products. Samples of new materials can be prepared in sizes suitable for accurate and complete evaluation of their properties; equipment can be developed and processes evaluated on a scale sufficient to provide an accurate estimate of technical and economic feasibility.

To maximize the utility of the Metals and Ceramics Building, to the General Electric Co., some means for determining the kinds of activities that shall be undertaken must be established. The interest of the General Electric Co. in metals and ceramics is of great breadth. Virtually any effort to create new materials and better processes would prove useful to the electrical industry. Nevertheless, it is believed that judgment and knowledge can maximize the utility of the Metals and Ceramics Building. To this end, two sets of information are needed.

First, there is the need for a flow of basic knowledge about the structure, properties, kinetics and equilibria of solids into the comprehension of those researchers concerned with the development of new materials and processes.

Secondly, there is the need for summarizing the materials needs for the thousands of energy converting products which the General Electric Co. now manufactures or might profitably manufacture in the future. This is an information gathering and analyzing mission to which a large part of the Research Laboratory staff of scientists contributes.

Finally, the financial value of each potential material development project and its probability of success must be estimated. By relating the knowledge to the need and appraising the opportunities for successful materials developments, the scientists who operate the Metals and Ceramics Building hope to apply their efforts to the projects with greatest promise for improvement of tomorrow's products. Their success in this endeavor will determine how effectively and how rapidly they can translate new knowledge into better living for the world's peoples. The new Metals and Ceramics Building offers the world's finest facilities to assist them in their task.



***Low alloy-high strength steels*** *were developed for outdoor service where there is a penalty for dead weight. Hence, high strength and resistance to atmospheric corrosion are important requirements.* *(U. S. Steel Corp.)*

# Special Uses Call for Tailor-Made Steels

*New steels and modifications of existing ones are in demand to meet the severe and exacting requirements of today's applications.*

**by A. M. Hall,** *Chief, Alloy Development Div., Battelle Memorial Institute*

■ Increasing specialization in products and processes, and higher demands upon materials to serve under tremendous stresses at very high temperatures or under other severe conditions, call for steels to meet the specific conditions. In many instances, existing compositions will not do the job. In others, available steels prove costly because of the necessity of frequent replacement or of poor performance.

As a result, there is a steadily increasing tendency to "tailor make" steels for a particular use or a relatively narrow group of uses. Each year ushers in a large crop of "new" materials. Some are soon discarded; others find important engineering applications. Most of them are modifications of existing materials and represent extensions of knowledge in the corresponding areas of metallurgical technology. A few are genuinely new, and their development has involved major technological contributions. In most cases, extensive research is involved in the new developments.

## Ultra-high strength steels

During the past few years, a number of low alloy hardenable engineering steels have come into use under conditions requiring ultra-high strength combined with acceptable ductility, fatigue strength and notch toughness. Steels comprising this group include some well established conventional grades and some new compositions. These steels were used originally in aircraft landing gear and airframe components because their higher elastic modulus, and high strength gave them a definite advantage over aluminum alloys. They are now used for machine and automotive components, shafting, gears, and other applications where high strength is required.

One of the first of these steels was AISI 4340, which is comparatively notch tough when heat treated to 180,000 psi tensile strength. However, when heat treated by conventional procedures to higher strength levels, its notch toughness drops sharply. Development of a special heat treating schedule permits 4340 to be hardened to 260,000-280,00 psi tensile strength while its other mechanical properties remain acceptable. This steel compares favorably in impact properties with, and is superior in fatigue properties to, the aluminum alloys giving satisfactory service in landing-gear components and attachment points. The adoption of AISI 4340 to ultrahigh strength applications exemplifies tailor making through improved know how.

Other ultra-strength steels that have been developed recently are deep hardening, similar to AISI 4340. To retain as much ductility and toughness as possible, carbon content is held to the minimum required for attainment of the desired strength (about 0.25-0.40%). Silicon, manganese, chromium, nickel, and molybdenum are balanced to produce the desired depth of hardening, and to prevent formation of microconstituents other than martensite, which would be undesirable.

Several factors limit the use of steels hardened to very high strength levels. These include instability at elevated temperatures, susceptibility to stress-corrosion, decarburization, and hydrogen embrittlement. Steps can be taken to overcome some of these disadvantages. At the same time, ease of fabrication and price are important advantages. Much research remains to make these steels more satisfactory, as well as to meet the pressure of the aircraft industry for ever higher strength-to-weight ratios. The development of suitable steels with tensile strength over 400,000 psi will not be surprising.

### Low alloy-high strength steels

Over the years, a special family of steels has emerged which is tailored to a variety of tonnage applications requiring a relatively inexpensive high strength, easily fabricated and readily welded construction material. This family of low alloy-high strength steels comprises some twenty proprietary compositions. Typical uses include railroad rolling stock, shovel buckets, mine car bottoms, bus and trailer bodies, earth moving equipment, low temperature turbine buckets, and pressure vessels. A common denominator of these applications is that they usually involve outdoor service and a penalty for dead weight. Hence, high strength and resistance to corrosion by the atmosphere are important materials requirements.

A newcomer to the family is a low carbon, low alloy steel possessing high strength combined with good ductility and impact properties. Major alloying elements are small quantities of nickel, chromium, molybdenum, copper, and boron with 0.15% carbon. Composition may be altered to meet various minimum tensile strength requirements. This steel is available as constructional plate material, hot rolled bar stock, and forgings. It is heat-treatable. Optimum properties are obtained by water quenching from 1650 F followed by tempering at 1150-1200 F, and quenching to room temperature. Preheat is unnecessary for welding if low-hydrogen electrodes are used. Welded joints possess 95% efficiency without a stress relieving treatment. The steel exhibits excellent toughness, and is reported to be satisfactory for subzero temperature applications down to —50 F.

### Low alloy steels for high temperature service

Large tonnages of low alloy steels are used in a variety of elevated temperature applications up to about 1100 F. Prominent among such uses are steam piping, boiler and superheater tubing, plate and piping for oil refining equipment, and structural components for furnaces and chemical processing equipment. Frequently, these steels contain molybdenum or molybdenum and chromium as alloying elements.

Although the maximum service temperature is not affected appreciably, elevated temperature properties of such steels can be increased significantly by small additions of titanium and boron. Both elements must be used to attain the desired properties. Boron should be added in amounts of 0.01-0.1%, and the titanium content should be approximately 2 to 4 times the carbon content to secure the desired properties. Boron and carbon appear to form a hard low temperature transformation product exceptionally resistant to tempering

Maximum elevated temperature strength properties are obtained by quenching from 2000-2100 F. As an illustration of the effect of titanium and boron, a 0.15 C-3 Cr-1 Mo steel has a rupture strength of 11,500 psi for 1000-hr life at 1100 F, while a 0.06 C-3 Cr-1 Mo-0.30 Ti-B alloy shows a rupture strength of 30,000 psi for 1000 hr at the same temperature. This exemplifies tailor making through research and development.

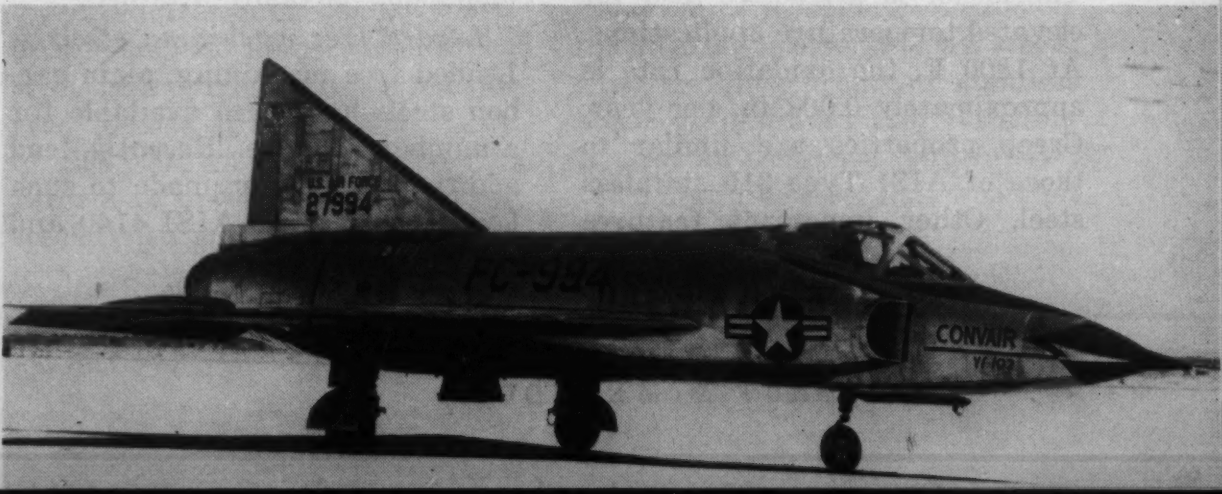
### Stainless steels

Interest continues in the field of precipitation-hardenable stainless steels. These materials are useful for service in steam power plants and aircraft applications at intermediate temperatures. 17-4PH is representative of these alloys. The composition is normally balanced to produce a metastable austenitic microstructure that transforms to martensite on rapid cooling from austenitizing temperatures. In the hardened condition, precipitation-hardenable stainless steels suffer from low ductility and low impact strength. Stability at elevated temperatures is also a problem, but can be improved somewhat by titanium or columbium additions.

AM-350, a precipitation-hardenable stainless containing molybdenum and silicon, recently became commercially available. The optimum strength properties of this alloy are obtained by quenching from the austenitizing temperature, refrigerating at —100

**Ultra high strength steels** *are used in aircraft landing gear and air-frame components because their higher elastic modulus and high strength enable them to compete on a strength/weight basis with aluminum alloys.*

*(Consolidated Vultee Aircraft Corp.)*



F, and aging at 800 F for 1-2 hr. The AM-350 alloy has lower tensile and yield strengths than 17-4PH but superior ductility. Thus, the impact strength of AM-350 is 36 ft-lb at −40 F in the hardened condition. The alloy has a high rate of work hardening. Yield strengths about 200,000 psi can be obtained readily by cold working.

AM-350 is useful for elevated temperature service up to 1000 F. Service at higher temperatures is limited by the formation of austenite at temperatures above 1150 F. Compared to AISI Type 410 stainless steel, AM-350 has superior elevated temperature properties. For example, at 900 F, the short time tensile strength is 159,000 psi, while Type 410 has a tensile strength of 65,000 psi. The 1000-hr rupture strength of AM-350 at 900 F is 98,000 psi.

A precipitation-hardenable cast stainless steel known as V2B is also commercially available. Its anti-galling properties make it useful for valve disks, plug cocks, shaft sleeves, impellers, pump casings, and gear blanks. Maximum hardness is produced by water quenching from 2000 F and aging for 8 hr at 925 F.

### Specialty alloys

Further development of iron-aluminum alloys has occurred recently. One alloy in particular, known as Thermenol, containing approximately 14 aluminum, 4 to 5% molybdenum, balance iron is interesting because of its superior magnetic properties and high electrical resistivity. It has very high magnetic permeability and low hysteresis losses, and therefore may be satisfactory for electronic applications and transformer cores.

Because of exceptional oxidation resistance, due to the formation of a thin, adherent, protective film of aluminum oxide, Thermenol is attractive also for elevated temperature applications. At 1800 F, the oxidation rate is approximately 0.008 in. per year. Creep properties are similar to those of AISI Type 310 stainless steel. Other important features are its low coefficient of thermal expansion and its excellent bonding properties to glass.

### Tool steels and free machining steels

Improvements have been made recently in the field of high alloy tool steels. These developments have been based on the principle that if elements can be added to engineering steels to make them free machining, why can't additions be made to tool steels to improve their machinability? The evidence indicates that this is a sound proposition.

*Sulfurized tool steels*—Various grades of molybdenum-tungsten-vanadium, chromium-molybdenum-vanadium, and high-carbon high-chromium high-speed and hot-work steels are available which have been sulfurized to improve their machinability. Substantial savings in tool production can be realized by sulfur additions without adverse effects on toughness and other mechanical properties. Moreover, sulfurized tool steels seem to perform better than conventional types apparently having better cutting edges, and needing less frequent sharpening. Sulfur additions are not detrimental to fatigue strength or forgeability if the sulfur content is carefully controlled. The optimum value is about 0.12%.

Sulfides in tool steels apparently act as internal lubricants and decrease frictional heat. This role of sulfides is different from that in free machining steels, where the sulfide inclusions break up the chips. Sulfides are added to tool steels as molybdenum disulfide or iron sulfide, and successful application depends on the ability to produce randomly dispersed sulfides rather than elongated stringers. Sulfide particles tend to be associated with the carbides in steels and hence the dispersion is easily attained.

*Leaded free machining steels*—Leaded free machining, plain carbon steels have been available for a number of years. Recently, lead additions have been made to such low alloy steels as AISI 4140 and 8620. Annealed leaded AISI 4140 can be cut at the same speeds as C-1117, a high carbon, high manganese steel with a machinability rating about 85% that of B-1112. Heat-treated leaded alloy steel machines 50% faster than a heat-treated alloy steel of comparable analysis without lead. It is reported that leaded AISI 4140 responds to heat treatment in the same manner as the unleaded grade, with equivalent ductility and notch toughness.

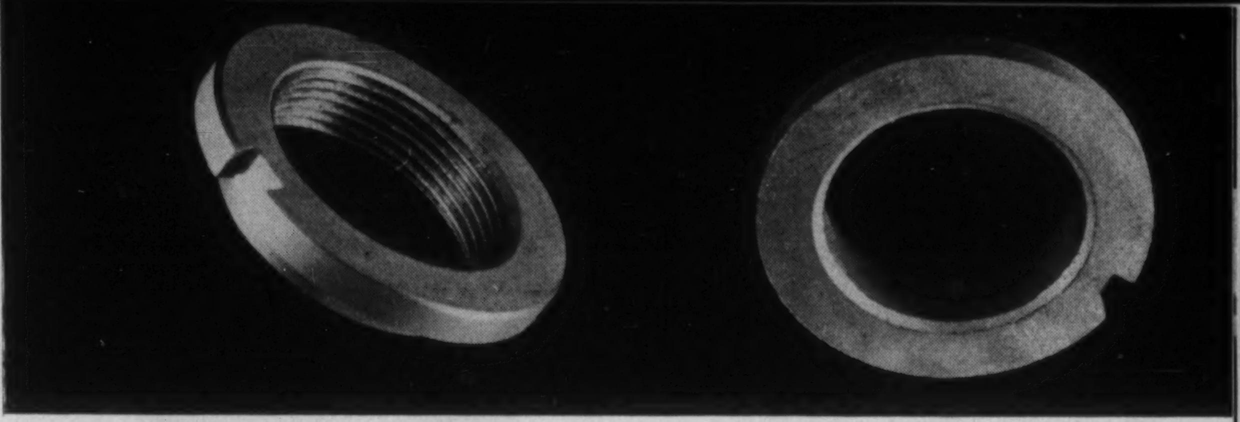
### Powder metallurgical products

In the powder metallurgy field, some recent developments have been concerned with more extensive application of sintered iron powders for special purposes. Some success has been attained in deep drawing pressed and sintered preforms into finished products. Hydrogen reduced iron powder is normally used for these processes rather than the more expensive electrolytic iron powders.

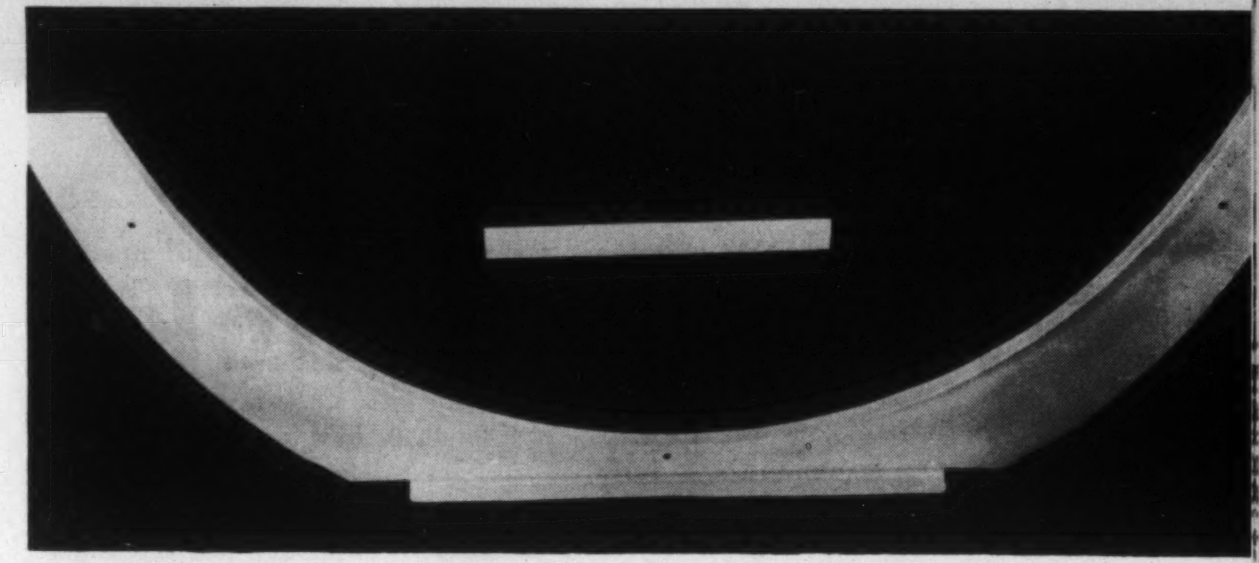
*Alloy steels*—Research has shown that the mechanical properties of iron powder compacts can be improved greatly by the addition of carbon, nickel, chromium, and other alloying elements. Better properties are obtained if chromium and nickel are introduced in the form of prealloyed powders rather than as the powders of the individual elements. Normally, 1% carbon is used. Sintering is carried out under 50 tsi pressure in dry hydrogen at 2200 F for one hour and shrinkage is of the same order of magnitude as for regular iron parts. The addition of lubricants improves processing. The best alloy additions thus far are 2.5% of prealloyed 80 chromium-20% nickel powders or 7.5% of prealloyed 50 chromium-50% nickel powders.

These powder produced alloy steels have high strength properties and excellent wear resistance. They respond well to heat treatment. Potential applications include gears, cams, rollers, eccentrics, and other intricate parts.

*Infiltrated products*—Work has continued in the development of infiltrated powder metallurgical



**Copper impregnated iron powder parts** *have improved properties because the copper fills the pores and reduces the number of " internal notches" in the sintered product.* (The Presmet Corp.)



**Precipitation hardenable stainless steels** *were developed to permit hardening of austenitic steels by thermal treatments. This section of a fuselage frame for a jet fighter could not be fabricated from Type 302 stainless but was formed from 17-7PH.* (Armco Steel Corp.)

products. The technique is the production of porous sintered metal skeletons, followed by impregnation with materials of good wettability and limited solubility for the parent skeleton. During impregnation, the temperature is close to the melting point of the infiltrant, and the time is controlled to limit alloying. Melting point of the infiltrant should be considerably lower than that of the parent material.

Infiltrated products have greatly improved properties because impregnation, by filling the pores remaining from the sintering operation, reduces the number of "internal notches" inherent in a sintered compact. Great increases in strength are thereby possible. The attainable properties depend on the wettability and solubility relationships of the impregnant.

Various applications of such materials are presently being realized. Teflon-impregnated products are utilized as self-lubricating bearings. Refractory oxides have been impregnated with liquid metals. Tungsten or molybdenum compacts infiltrated with copper or silver are used as electrical contacts because they are resistant to wear, are nonsticking, and have low losses from arcing.

Copper impregnated sintered iron materials are presently being used for compressor stator blades in the J-35 turbojet engine where resistance to impact and fatigue are required. A 50% saving in cost over that of a forged AISI 403 stainless steel blade is reported. The compact contains about 25% copper and up to 1.0% carbon and 0.3% silicon. The mechanical properties are 100,000 psi tensile strength, 75,000 psi yield strength, and 6% elongation in 2 in. This material is also being used for such applications as washing-machine wringer drive-gears and gears for business machines. In such applications, it replaces hot rolled C 1015 steel which must be pierced, flattened, and machined.

### What about the future?

Forces that have stimulated the general technological growth of the United States are, by their nature, responsible for the trend toward specialization of metallic materials. Therefore, it can be anticipated that the demand for specialization or "tailor-making" will continue and strengthen.

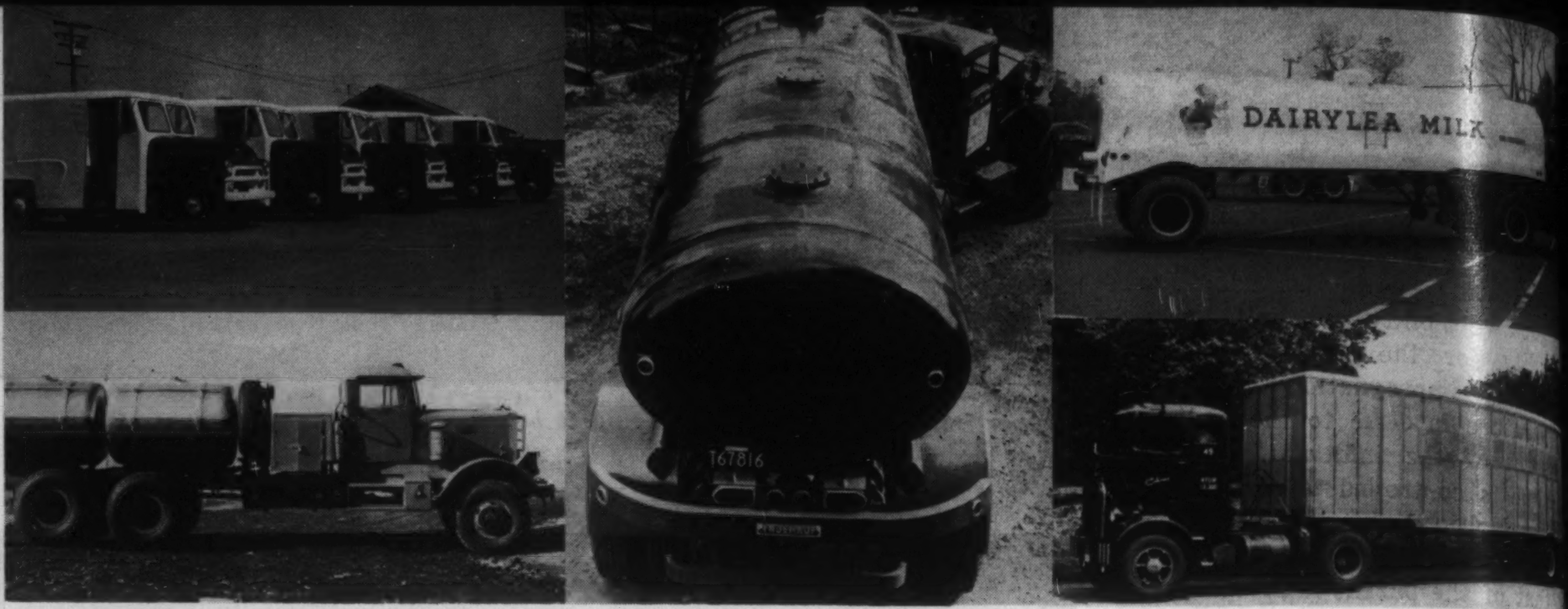
Iron is plentiful and will continue into the distant future to be one of the important pillars of material civilization. Though iron alloy systems have already contributed scores of special compositions developed for particular uses, the potentialities of iron alloys for further tailor-making are enormous.

The trends in the aircraft industry place an increasing premium on materials of high elastic modulus and high strength-to-weight ratio. Iron alloys have made a good start in meeting these requirements, but much improvement is necessary. These steels are currently being considered for use at strength levels up to 290,000 psi tensile strength. Efforts to develop much stronger steels with satisfactory ductility, toughness, and fatigue strength are worthwhile.

The aircraft industry will also need a reasonably oxidation resistant material of good formability capable of retaining high strength at temperatures up to about 700 F. Present age-hardenable stainless steels are a step in this direction. However, they need much further development, particularly with regard to consistency of mechanical properties and simplification of heat treatment.

The power industry could use a high chromium tube steel that is weldable and has good creep resistance up to at least 1200 F. It should contain perhaps 25% chromium to improve its resistance to flue-gas atmospheres.

There would be many uses for a low alloy steel of superior resistance to atmospheric corrosion, for ultra-high strength cast steels, for straight chromium stainless steels of improved cold formability, for an iron-base "superalloy", for a stainless steel that won't pit in sea water.



# Plastics Trucks Roll

- *Better thermal and acoustic insulation,*
- *Lighter weight,*
- *Ease of maintenance,*
- *Design flexibility . . . have won a secure position for reinforced plastics in truck body construction.*

**by Theodore B. Merrill Jr.,** *News Editor, Materials & Methods*

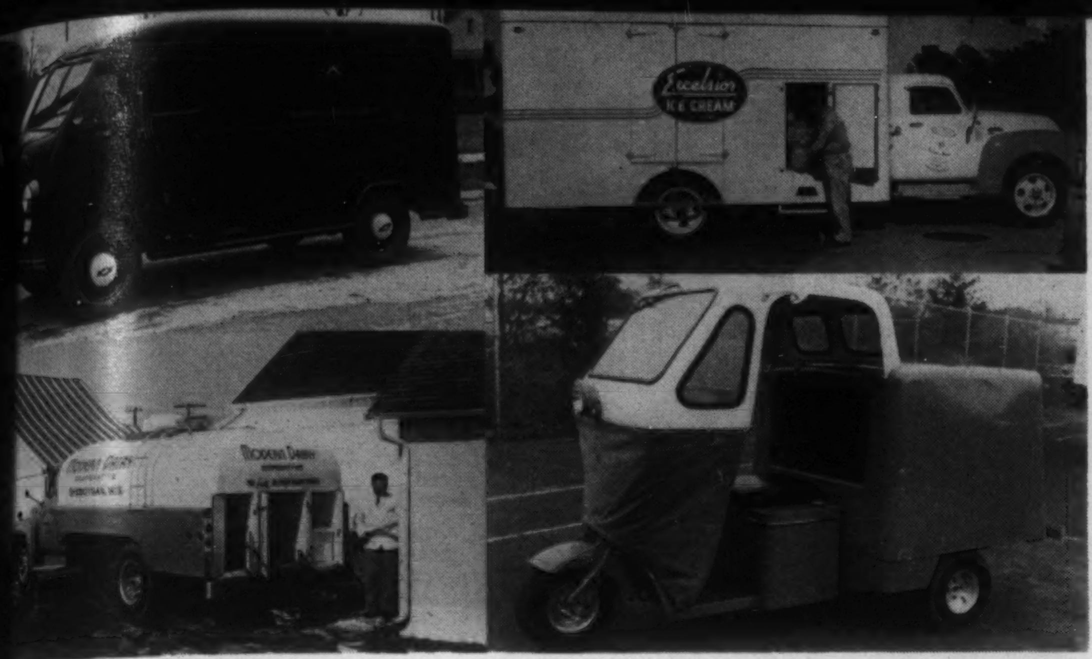
■ The number of trucks on the road with reinforced plastics bodies is scarcely a drop in the bucket compared to standard mass produced vehicles. But as pictures on these pages show, many types of plastics truck bodies are actually in service and more are on the way.

To date, design flexibility has been the keystone of plastics in truck production — automobile manufacturers learned that it costs less to make a few experimental bodies out of glass reinforced polyester than to hammer them out of metal, and truck makers have taken the cue. Because of somewhat lower tooling costs, plastics moldings are economical for limited production runs despite high per-pound material cost. In terms of the number of units produced, just where the breakeven point between die formed metal parts and molded plastics parts occurs is still subject to hot debate. Proponents of short run production of plastics-die formed metal parts over metal-die formed plastics parts no longer accept the figure of 15,000 units, the breakeven point estimated in an SAE paper over a year ago. Lack of experience with such long production runs indicates that the debate will continue.

The concern with the relative costs of plastics and metal has tended to obscure other relevant factors in the selection of one material over another for the production of truck bodies. Operators who have had experience with all-plastics truck bodies are enthusiastic, in general, and several have announced an intention to replace their fleets with plastics trucks as their present equipment wears out. Their reasons include better performance, lower maintenance, and lower operating costs. Such advantages in plastics truck construction have considerable merit, though the inherently higher per pound cost of plastics, coupled with slow molding cycles, limits the use of plastics to relatively short run production schedules. As a rule, fleet owners are still suspicious of plastics as structural materials. Sales resistance is high, and in order to sell, plastics bodies must have significant superiority over standard, mass-produced trucks available at less cost.

### Advantages

There does exist a definite need



**Plastics bodies** *for trucks meet requirements for a wide variety of body types. Illustrated (top to bottom, left to right): Multi-stop deliveries, by Permoglas, Inc,; Off the road tank, by Carl N. Beetle Plastics; Liquid chemical semi, by C. N. Beetle; Milk tank semitrailer, by Heil Co.; Semi-trailer, by Strick Plastics Co.; Multi-stop delivery, by Montpelier Mfg. Co.; Farm milk pick up, by Heil Co.; Insulated refrigerator, by Permoglas; and Mail route scooter, by Lunn Laminates.*

for specialty truck bodies, and the fact that most trucks are not made in passenger car quantities puts plastics in a reasonably competitive position. Few other materials can match reinforced polyesters in the following categories:

*Design flexibility* — One-, or few-of-a-kind specialty bodies are less costly in plastics, particularly compound-curved sections. Wood, plaster, and plastics tooling, with molds made from original mock-ups, cut costs significantly. For experimental units, such as the three-wheeled mail delivery van molded by Lunn Laminates, Inc., glass reinforced polyester is a logical choice of material.

*Weight reduction* — The high strength-to-weight ratio of large reinforced plastics moldings, combined with resiliency and resistance to denting, makes possible much lighter assemblies. Truck operators calculate that each pound reduction in dead weight on a truck in daily service results in a direct savings of 1¢ per day. Multi-stop delivery trucks, as built by the Strick Plastic Co., Montpelier Manufacturing Co., Lunn Laminates, Inc., and others, weigh 500 to 1000 lb less than standard aluminum-steel bodies, providing a potential reduction in operating cost of $5 to $10 per service day.

*Corrosion resistance*—Polyester glass-fiber laminates have turned in good performance where high detergency cleaners are used. Fewer seams and joints are present to start corrosive deterioration. While no electrolytic or oxidation type of corrosion will occur, a few polar solvents will attack the material. The material is highly resistant to weathering, gasoline and lubricating oil.

*Insulation*—Plastics panels and moldings are excellent thermal insulators. Milk delivery trucks manufactured by Permoglas Inc., in fleet service for some time on the West Coast, undergo an interior temperature change of less than 8 F during delivery of a full load of milk to an urban route. Tank trucks, manufactured by the Heil Co., in use delivering fresh orange juice from Florida to New York take on chilled juice at 32 F, and without further refrigeration, deliver it in New York 40 hr later at 34 F. Smaller Heil tank trucks used for farm milk pick up have a plastics molded tank with a thin stainless steel liner. Because there is no metal to metal connection between tank and frame, the thermal insulation for the cargo is excellent.

*Translucency*—Unpigmented, or lightly pigmented polyester-glass laminates will transmit light. Most large truck manufacturers now offer skylighted trailers with translucent reinforced plastics roof panels or shoulder caps. Some of the all-plastics multiple stop delivery trucks for other than dairy use have an unpigmented section in the roof.

*Damping factor*—Plastics bodies are more resistant to denting, due to the resiliency of the reinforced laminates. The thicker plastics sections have a high damping factor for sound, which, combined with fewer parts than are found in metal construction, provide a quieter running, rattle-free vehicle. Driver reports on

**Interiors** *of plastics truck bodies are smooth, easily cleaned with hose or steam jenny. Note how translucent panels in Strick Plastic Co.'s semitrailer (upper left) and Montpelier Mfg. Co.'s skylighted multi-stop delivery (lower left and right) provide excellent working illumination in daylight.*

***Big moldings*** *mean fewer parts for plastics truck construction. At upper left, molders apply polyester resin to fiberglass mat in female vacuum bag mold. At left, entire side panel is removed and after trimming and sanding, is assembled with other plastics moldings (above).*

*Lunn Laminates, Inc.*

noise are highly favorable, and fleet owners report less driver fatigue, although this may be due to easier handling due to lighter weight.

### Production of plastics bodies

Manufacturers use all the standard reinforced plastics construction and fabrication techniques for various types of plastics trucks and trailers. A number of trailers have metal frames, with plastics panels additionally reinforced with structural plastics spacers. Strick Plastic Co.'s large semitrailers for Celanese have all metal frames and translucent plastics panels on the top and sides. Strick has also produced a prefabricated modular truck body kit, from which truckers can assemble their own trailers. The basic plastics component of the kit is a patented sub-structure called Lamicore, which is a standardized panel with inner and outer skin of polyester-glass laminate on a reinforced plastics frame. The panel's hollow core contains thermal insulation material.

Most of the smaller, multi-stop delivery vehicles are fabricated from large custom moldings, as are all liquid transport trucks. Hand lay up, vacuum bag, and matched metal molding techniques have been and are in use; the ultimate choice of method depends on the quantity of bodies produced.

For low production or custom jobs, hand lay up and room temperature cure at atmospheric pressure on plaster or wooden molds is customary. While least costly for a single body, this method is the most expensive per unit for volume production and does not produce the strongest or most uniform structure. For fleet orders, the majority of plastics truck body molders use vacuum bag techniques. Some tank trucks and a pick up truck body have been made from sections molded in matched metal dies, which produce the best moldings, considering uniformity of physical properties and surface finish.

Molded reinforced plastics truck structures can be painted and baked after assembly, but recent practice has tended more toward the use of pigmented resins, providing molded-in colors. Such moldings are chip proof, have longer service life and high resistance to repeated cleanings.

Reinforced plastics are no longer in the experimental class as truck body materials. They have carved a permanent niche for themselves as skylight materials in standard body construction and as a structural material for refrigerated cargo carriers. Though plastics may never be able to compete on a direct cost basis with mass produced metal bodies, the future of plastics trucks for specialty service seems assured.

### Acknowledgements

Barrett Div. Allied Chemical & Dye Corp.
Bigelow-Sanford Fiberglass Div.
Carl N. Beetle Plastics Corp.
Celanese Corp. of America
Fabricon Products Co.
Heil Co.
Hooker Electrochemical Co.
Lunn Laminates, Inc.
Montpelier Manufacturing Co.
Owens Corning Fiberglas Inc.
Permoglas Inc.
Reichhold Chemicals, Inc.
Strick Plastic Co.

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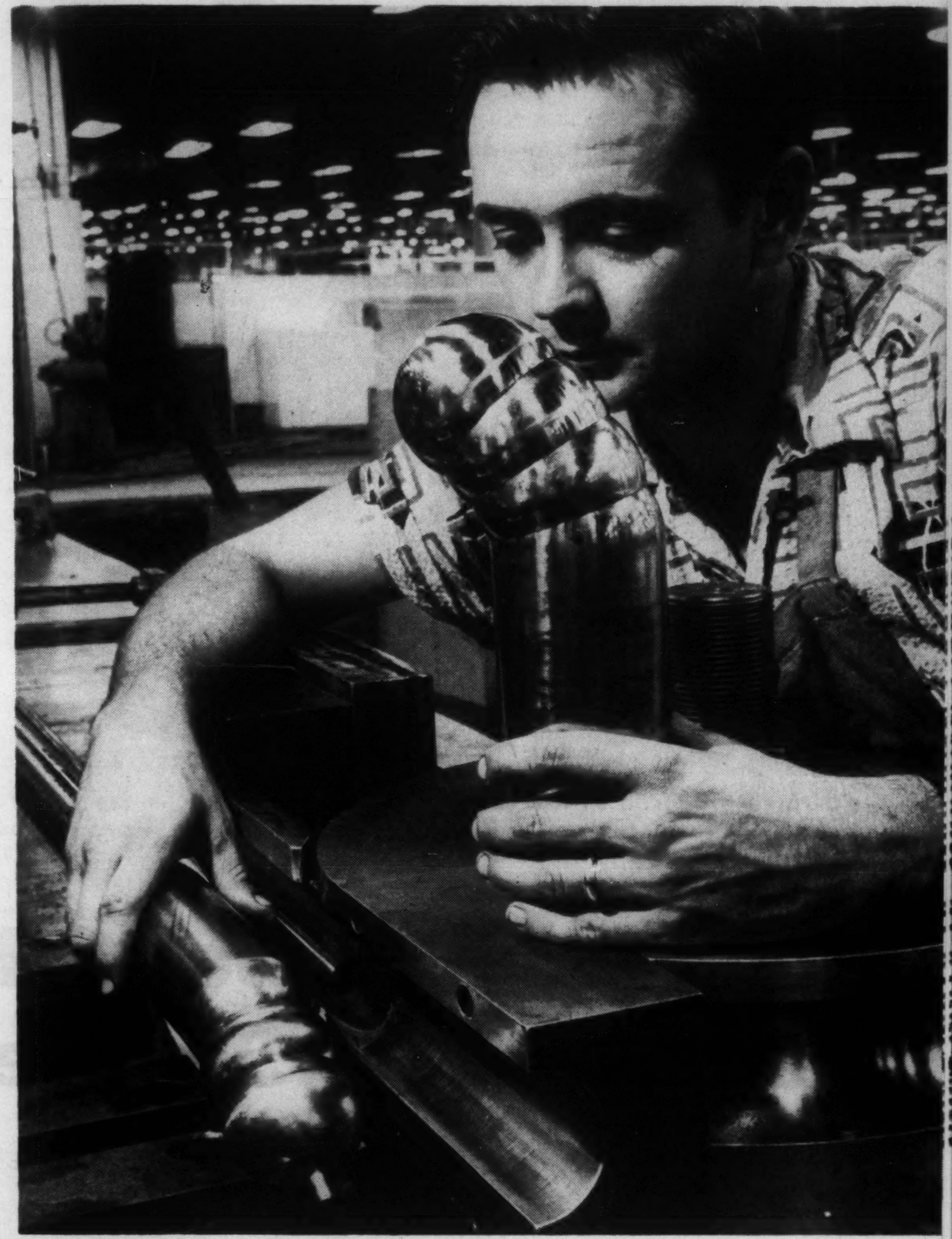
# Materials at Work

*New and old materials in unusual applications*



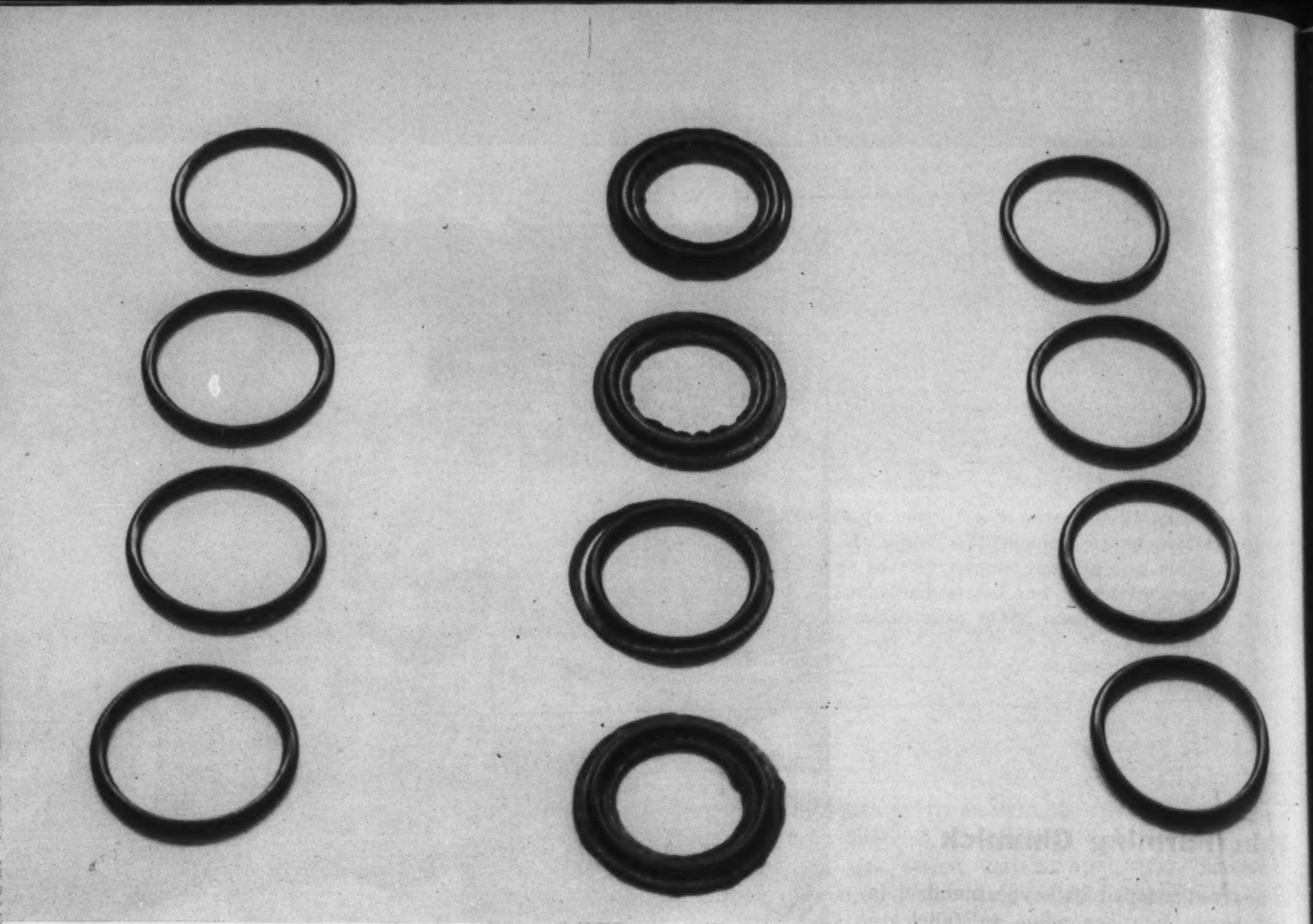
## Tube Forming Gimmick

A newly developed ball-type mandrel is said to be less expensive to fabricate than conventional ball-type mandrels and to provide other economies when used for tube forming. Developed by a tube-bender at Temco Aircraft Corp., the mandrel uses dished-out steel hemispheres similar to conventional bell-type mandrels. But instead of the conventional links, which allow the mandrel to swivel in only one plane, the new device is joined by a cable, allowing it to swivel in any direction like a goose-neck lamp. Use of the tool results in a reduction of about 15% in set-up time, a lower rejection rate, and provides a smooth, well-formed tube.

## Gold Plated Parts

These electrical components have been plated with a bright gold plate which lends them resistance to corrosion, seizing and galling. They have been plated by a new process developed by Sel-Rex Precious Metals, Inc. Other advantages of the plate are said to be a hardness of Vickers 115 compared with 65 for ordinary gold, exact duplication of surface and superior throwing power.

*More Materials at Work on pp. 107 and 111*



**O-rings produced** *by new process (left). Note absence of flash. Center, O-rings produced by compression molding before stripping flash. Right, O-rings produced by compression molding after stripping of flash.*

# Improved Rubber O-Rings for Hydraulic Service

*New high speed molding process practically eliminates internal stresses. . . . Result: O-rings that can withstand severe distortion in service.*

**by Gilbert C. Close**

■ Improved rubber O-rings with strengths almost equal that of the base material are now possible. Where formerly O-rings developed only around 50% of the elastic strength of rubber, use of a new molding process increases this figure to better than 90% of the strength of the base material.

Older rubber molding processes—injection, compression and transfer—cause internal laminations and stresses within the structure of the O-ring. The new molding technique, called the Dauby Process and developed at Plastics and Rubber Products Co., has practically eliminated these defects. As a result, O-rings are now being produced that will absorb severe distortion in service without failure or permanent set. In addition to producing higher strength properties, the new technique lends itself to high speed production.

The word, "normalized," serves to describe the essential feature of the Dauby Process. As a rough comparison, the O-rings are like steel parts that have been normalized after work hardening or heat treatment to relieve internal stresses. To produce these normalized O-rings, this new high speed molding process was evolved which rapidly and uniformly vulcanizes the rubber during the molding operation.

## Old method

The limiting condition with the

older molding processes was the appreciable time lag between the time the raw material entered the die cavity and until total molding pressure was obtained. In compression molding, this time lag occurred between the placement of the rough cut parts and the closing of the die. In either injection or transfer molding, the lag occurred while the die cavity was being filled. In either case, as soon as the base material contacted the hot die cavity, it began to vulcanize. When a compression die was closed to produce the necessary pressure and flash, only that part of the material which had not started to vulcanize would flow to fill the die cavity and produce the flash. And in injection or transfer molding, only that material entering the die cavity last would flow to fill the contours of the die.

This partial movement of the material within the die cavity produced laminations within the structure of the material. When molding pressure was relieved after vulcanizing was complete, the O-ring material would attempt to adjust itself, not as a body, but along the planes of various laminations formed during molding. The result was a series of internal stresses which had to be canceled by the elasticity of the material, thus subtracting from its usable elastic limit.

## New method

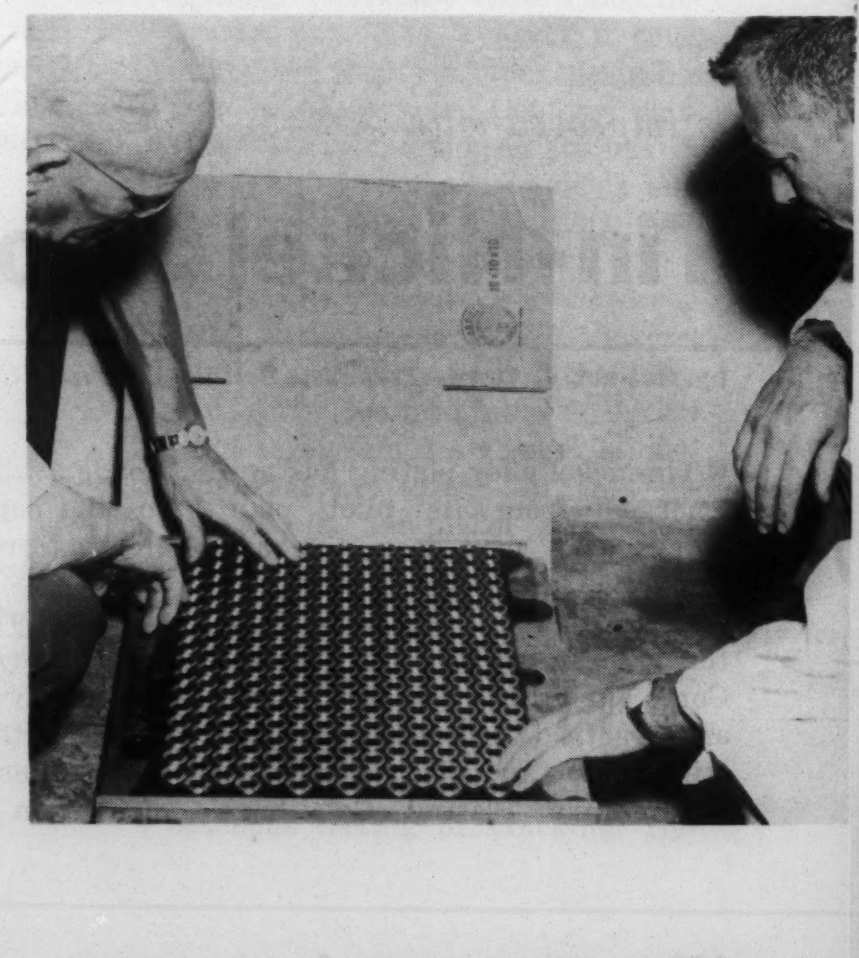
The new molding technique, while patterned in some respects after compression molding, has two important advantages. First, the time lag in filling the die cavity has been reduced to the vanishing point. Thus, none of the material has time to become even partially vulcanized before the die cavity is filled. Second, the amount of material introduced into the die cavity is exactly equal to the amount of material required for the part. There is no excess material to produce a flash and cause a pressure increment when the die cavity is filled. Thus, when the pressure on the molds is released after vulcanizing, there is no tendency for the molded material to readjust its dimensions, and no laminated planes within the material along which stresses can form in case even a slight readjustment is necessary.

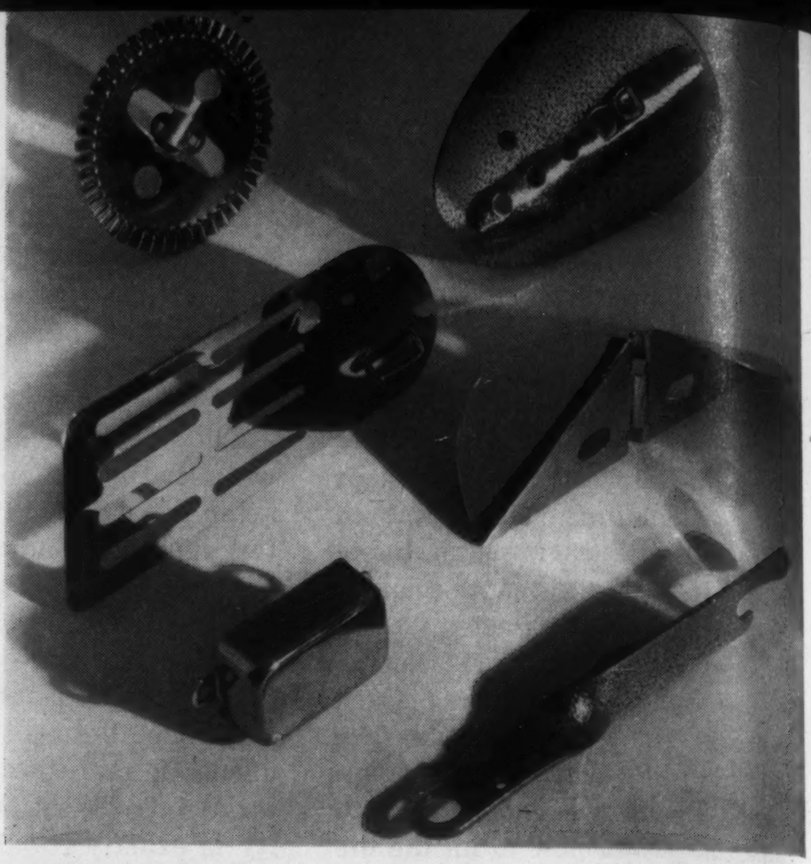
The die itself is the most important innovation of the process. To draw a rough comparison, it resembles an old-fashioned cookie cutter with several separate compartments which cuts several cookies from a large sheet of dough in a single stroke. In use, this multiple die for O-rings is placed in the molding machine and brought to the proper temperature. The die is then opened (it is constructed in matching halves), a sheet of rubber is slipped between the die halves; and, as the die closes, each of the die cavities cuts just enough material from the rubber sheet to fill it. The success of this operation depends on the intricate geometrical calculations used in designing the mating edges of each die cavity. When the die cavities close, all molding machine pressure is absorbed by the die without transmission of this pressure into the material being molded.

The speed of this new process over the older molding processes is obvious. Whereas three different operations were formerly required, the new machine cuts the raw material from sheet stock directly into the die cavity without the need of preparing roughs, and no flash is created which must be removed by hand after molding.

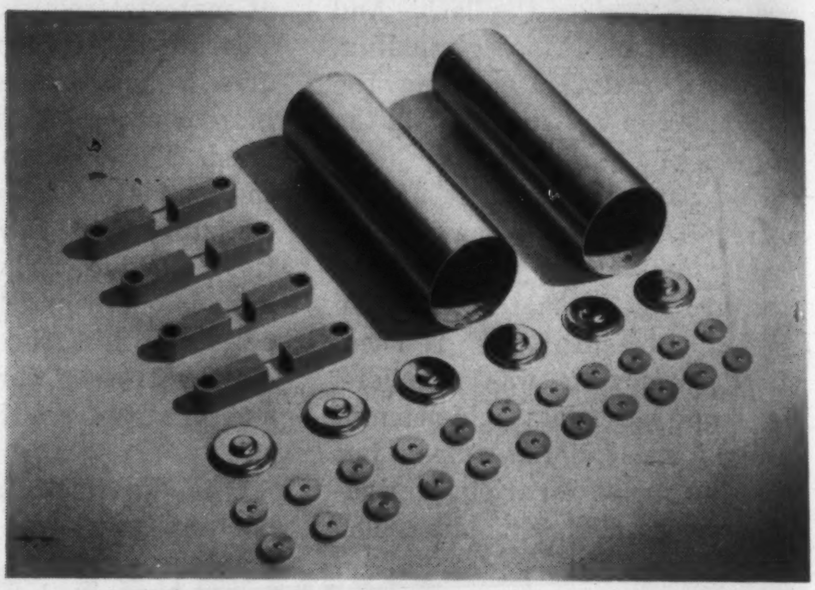
**Rubber sheet** *being placed between the parted die halves of molding machine used in the new Dauby Process. When the die is closed, each die cavity "cuts its fill" from the rubber sheet.*

**Multiple O-ring die half.** *Geometrical design of the die cavity mating edges assures cutting just enough material from sheet to fill the die cavity.*





*Thinner coatings of the alloy will plate bright on polished surfaces or can be buffed to pleasing luster when applied to dull surfaces.*



*Instrument brackets (upper left) are plated with tin-nickel for its corrosion resistance and nonmagnetic properties. The alloy plate on cylinders (upper right) provides solderability, color maintenance and corrosion resistance. Other parts shown are mercury battery caps (center) and gear train (bottom).*

*Appearance of consumer products . . .*

*Corrosion resistance of industrial parts . . .*

*is improved with . . .*

# Tin-Nickel Alloy Plated Coatings.

**by Robert T. Gore,** *Technical Service Engineer, Chemicals and Metals Div., Metal & Thermit Corp.*

■ Tin-nickel alloy plating has now emerged from its pilot plant stages as a new decorative and protective finish of unusual promise. Commercial development of the process by Metal & Thermit Corp. during the past few years, and practical applications in both still tank and barrel plating at Century Plating Co., have made available data on properties of the deposit and details of the plating process.

### Characteristics and properties

*Composition of deposit*—Available only by the electroplating process, the tin-nickel alloy is deposited as an intermetallic compound in the proportion of approximately 65% tin and 35% nickel. The composition of the deposit remains nearly constant over a wide range of operating conditions. Only insignificant changes in composition result from variations of as much as 20 to 30% in the content of either metal in the electrolyte. Century Plating Co. reports that it has not proved difficult to maintain constancy within 2%.

*Metals that can be plated*—Tin-nickel can be plated directly on most base metals including steel, cast iron, copper, tin, brass and bronze. The alloy cannot be deposited directly onto zinc or aluminum as these metals are rapidly attacked by the electrolyte. However, the tin-nickel may be applied over a copper or bronze undercoat. The bronze or copper strike may also be used under tin-nickel on steel where maximum corrosion-resistance is required.

*Plate thickness*—There is practically no limit to the thickness that may be deposited. Deposits up to 0.010 in. are being successfully plated. Such extreme thicknesses would not be used for decorative purposes or even for corrosion resistance; they are sometimes employed for build-up or abrasion resistance in engineering applications.

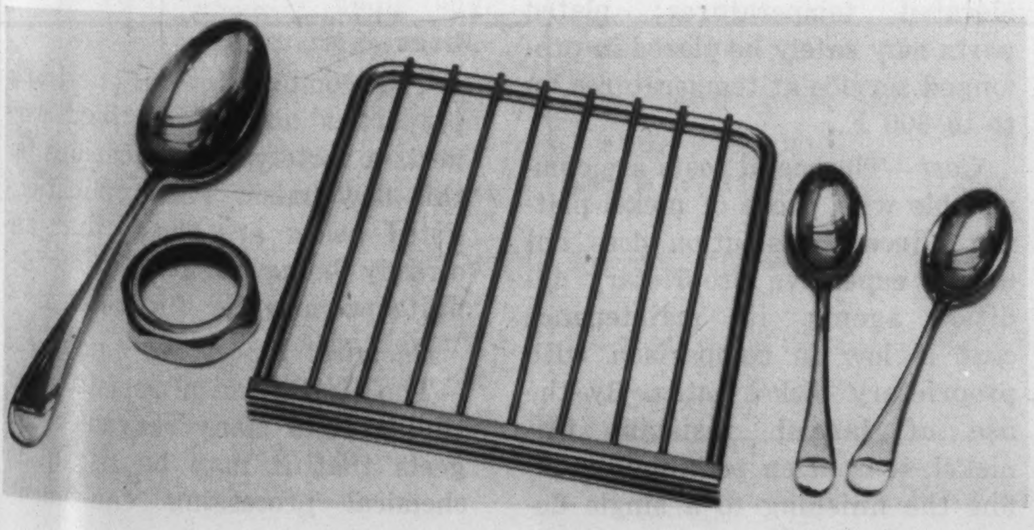
The plate has relative flat plating distribution which permits control of deposit thickness within close tolerances. For example, plug valve bodies and plugs, which have been machined to 0.003 in. for close fit, are being plated on the finished surfaces with no interference to correct seating. Articles with smooth contours may be plated with negligible variations in thickness.

*Throwing power*—The excellent throwing power of the tin-nickel solution is superior to that of nickel and practically all other solutions in wide use. Deep recesses may be plated without the use of special racks or internal anodes. The deposit covers the entire inner surface of hollow articles and, while somewhat thinner than on the exterior, is always of the correct composition. For example, ten-cup coffee percolator bodies, plated 0.001 in. on the outside, were coated to a thickness of 0.0002 to 0.0003 in. on the inside bottom without the use of inside anodes or special racking fixtures. The inside of the spout was completely covered. The same bodies, bright nickel plated under the same conditions, were only covered on the inside to a maximum of 2 in. down from the rim.

*Appearance*—Tin-nickel plate is easily color buffed to a pleasing high luster if the underlying surface is dull. Thin deposits will plate bright, even on irregular objects, if the under surface is bright. The color is considered by many observers to be more attractive than that of chromium or nickel, lacking the blueness of the one and the yellow tinge of the other. The color is not unlike that of stainless steel. In fact, parts that cannot be satisfactorily worked in stainless may be made of other materials, then plated to harmonize.

*Corrosion resistance*—In general, in heavy deposits the tin-nickel alloy is more resistant to corrosion than either tin or nickel alone. Deposits in excess of 0.001 in. in thickness afford outstanding protection. Tests of outdoor exposure and salt spray resistance are in progress, but are not sufficiently advanced to warrant publication. However, the experience with tin-nickel plated parts exposed to corrosive atmospheres has been highly favorable, as can be seen by reference to the table. P. R. Mallory's mercury battery covers, plated by Century and shown in one of the photographs, have proved highly resistant to electrolytic corrosion.

*Big advantage of tin-nickel plate on consumer items is its tarnish resistance.*



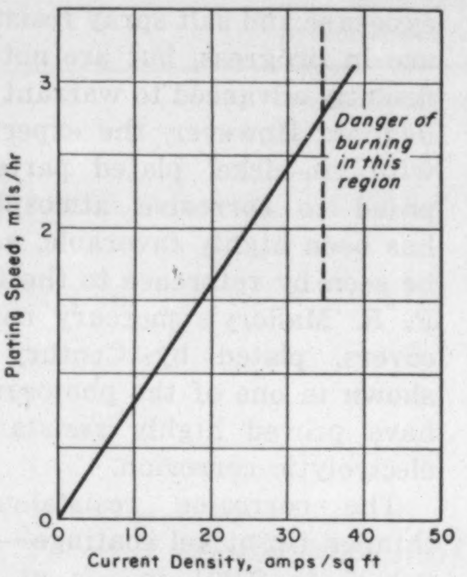
The corrosion resistance of thinner tin-nickel coatings—from 0.0005 to 0.001 in.—is at least equal to the same thickness of copper plus nickel. It is resistant to a wide variety of corrosive agents which corrode both of its constituent metals. An accompanying table shows results of immersion tests conducted on both nickel and tin-nickel deposits.

*Resistance to tarnishing*—Tin and nickel alone both tarnish in air and soon lose their initial appearance. However, when they are codeposited as an intermetallic compound, the alloy exhibits a resistance to tarnishing totally unlike the behavior of the constituent metals. In this respect it is equally as serviceable as chromium plate under a wide variety of conditions.

*Solderability* — The alloy is readily solderable with a noncorrosive flux. This property, in combination with its other desirable characteristics, led Century Plating Co. to recommend its use in sealed precision mechanisms and many electronic applications, with highly satisfactory results.

*Hardness and wear resistance*—The hardness, about 650 Vickers, and wear resistance of the plate are intermediate between nickel and chromium. Its good frictional qualities are useful in some applications. Tin-nickel plating of brass gear trains resulted in a 20% reduction in measured friction, according to Century.

*Ductility and internal stress*—The alloy is moderately ductile and entirely free of internal stress. It is not subject to spontaneous flaking or cracking. De-



*Rate of deposition.*

### The Plating Process

*Bath*—The solution is made up from readily available commercial chemicals as given below:

| | |
|---|---|
| Anhydrous stannous chloride | 6.4 oz per gal |
| Nickel chloride | 40.0 oz per gal |
| Ammonium bifluoride | 7.5 oz per gal |
| Ammonium hydroxide as needed to adjust | |

This produces a bath of the composition given below, which should be maintained within the indicated limits by the appropriate additions:

| | *Make-up* | *Control Limits* |
|---|---|---|
| Tin (stannous) | 4.0 oz per gal | 3.5-5.0 oz per gal |
| Nickel | 9.8 oz per gal | 8.0-11.0 oz per gal |
| Total fluorine | 5.0 oz per gal | 4.5-6.0 oz per gal |
| pH | | 2.0-2.5 |

During operation, the pH tends to rise very slowly. High pH causes a loss in brightness of the deposit and should be corrected by addition of hydrofluoric acid or ammonium bifluoride. The fluoride concentration must be maintained to secure maximum brightness over the widest current density range. The total fluorine concentration should always be at least as high as the total tin concentration. Operating temperature of the bath should be 155 F, plus or minus 5 F. The bath operates at approximately 100% cathode current efficiency, and at 25 amps per sq ft it will deposit 0.0005 in. in 15 min.

*Anodes*—Separate tin and nickel anodes are used in a ratio of approximately 2 nickel to 1 tin anode and are placed on common anode rods. This ratio of nickel to tin anode area is necessary because the tin anodes dissolve more readily in the solution. Cast tin anodes are recommended and should be bagged, preferably in nylon. Nickel anodes can be either rolled-depolarized or high purity cast anodes. Nickel anodes containing appreciable amounts of carbon are not advisable.

*Equipment*—The tank should be of steel, lined with either neoprene or rubber. If rubber linings are used, the free sulfur and filler content should be low. Heating of the solution can be accomplished by the use of either nickel heating elements or heavily nickel plated coils or immersion heaters. Pipes, pumps and filters can be lined with the same material used in the plating tank. Exhaust ventilation is required since the emanations coming from the heated solution contain small amounts of hydrofluoric acid vapor. For still tank plating, a power supply of 6 v is recommended. Tank voltages will be around 2 v for the average current density of 25 amps per sq ft. For barrel plating, a minimum of 9 v should be available.

*Preparation of work*—Conventional cleaning cycles are satisfactory. Since the deposit will be no brighter than the basis metal, the preparation of the undersurface is most important if a highly attractive finish is desired. To secure good adhesion when plating on stainless steel, the parts should be made anodic in the tin-nickel solution for 15 to 30 sec and then plated without removing them from the tank.

posits 0.012 in. thick have withstood grinding without showing any tendency to crack. Tin-nickel alloy plated materials cannot be formed after plating as is sometimes done with copper or tin. The permissible degree of bending is approximately the same as metal plated with bright nickel. The deposit exhibits good adhesion. If the bend is too sharp, the plate may crack but stays on.

*Magnetic properties*—Tin-nickel deposits are nonmagnetic. This property has led to its use in timing devices.

*Temperature resistance* — The alloy plate is stable at moderately elevated temperatures; plated parts may safely be placed in prolonged service at temperatures up to to 600 F.

*Cost*—The metal costs are comparable with those of nickel plating. Since the solution does not utilize expensive proprietary addition agents, its maintenance cost is low in comparison with proprietary nickel baths. By the use of tarnish resistant tin-nickel, it is often possible to confine the finishing to a single deposit, thus eliminating further costly plating operations.

### Uses

The combination of desirable properties already outlined suggests a variety of applications for this new finish. The applications listed below are those that are already being used or show definite promise for future use.

*Chemical processing equipment* —The high chemical resistance of tin-nickel to many reagents suggests that it may be useful in chemical processing equipment.

Pilot production studies at Century Plating Co. have tended to confirm this assumption and indicate the possibility of widespread use in pumps and flow control devices in chemical processing installations.

*Food machinery castings, etc.*—Tin-nickel over reflowed tin provides the smooth, hard, cleanable surface required for these applications where a primary function of the equipment is protecting the purity of the product.

*Parts difficult to cover by other methods*—Such parts can often be finished economically in tin-nickel because of the excellent throwing power of the bath. The cylindrical cases illustrated in the group photograph are being regularly plated by Century in a still bath without the use of auxiliary anodes.

*Small parts* — By economical barrel plating, such parts as screws, nuts, bolts, etc., can be given a pleasing, durable, tarnish-resistant finish at reasonable cost. The high throwing power of the tin-nickel solution insures complete and uniform coverage. In some cases the solderability of the plate may also be useful.

*Automotive and appliance parts*—Attractive finish, hardness, and corrosion and tarnish resistance combine to recommend the plate for these applications.

*Electronic parts*—For parts of higher priced TV sets, such as the chassis, tin-nickel supplies a highly decorative finish as well as corrosion resistance and solderability.

The possible fields of application for the tin-nickel alloy have not yet been fully explored; new uses are constantly being suggested. Thinner coatings of the bright deposit over a bright basis metal may be used to advantage on practically any metal presently being finished in nickel or nickel plus chromium.

Where heavier deposits of buffed nickel are ordinarily used, buffed tin-nickel can be advantageously employed to provide better corrosion resistance and a tarnish-resistant surface of pleasing appearance.

**RESISTANCE OF TIN-NICKEL TO CHEMICAL SOLUTIONS**

| Solution | Weight Losses (mg) | | Visible Change in Tin-Nickel |
|---|---|---|---|
| | Nickel | Tin-Nickel | |
| 1N Hydrochloric acid | 41.5 | 24.8 | Covered by adherent brown film |
| 1N Sulfuric acid | 25.6 | 14.5 | Slightly darkened |
| 1N Nitric acid | 97.6 | 1.1 | None |
| $\frac{N}{10}$ Sulfurous acid | 725 | 0.5 | None |
| 1M Formic acid (pH 1.8) | 35.5 | nil | None |
| 1M Acetic acid (pH 2.4) | 43.6 | 0.6 | Very slightly darkened |
| $\frac{M}{2}$ Oxalic acid (pH 1.1) | 16.4 | 12.0 | Etched on immersed area, dark stain at water line |
| 1M Lactic acid (pH 1.9) | 17.8 | 2.1 | None |
| $\frac{M}{2}$ Tartaric acid (pH 1.7) | 10.0 | 0.5 | None |
| $\frac{M}{3}$ Citric acid (pH 1.9) | 19.2 | 0.4 | None |
| $\frac{M}{2}$ Phenol (pH 2.3) | 0.3 | nil | None |
| 1N Sodium chloride | 1.0 | 0.8 | None |
| $\frac{M}{3}$ Ferric chloride (pH 1.5) | 303 | 2.3 & 6.2 | None |
| Sodium hypochlorite (40 gm per l available chlorine) | 625 | 22 & 67 | Bottom edge badly etched none elsewhere |
| Sodium hypochlorite (0.1 gm per l available chlorine) | 1.8 | 0.8 | None |
| 1N Caustic soda | 0.2 | 0.7 | None |

*Note: 3- by 1-in. specimens vertically suspended in solutions at 86 F with a length of 2.3 in immersed for 24 hr.*

*(Tin Research Institute)*

**RESISTANCE OF TIN-NICKEL TO CORROSIVE ATMOSPHERES**

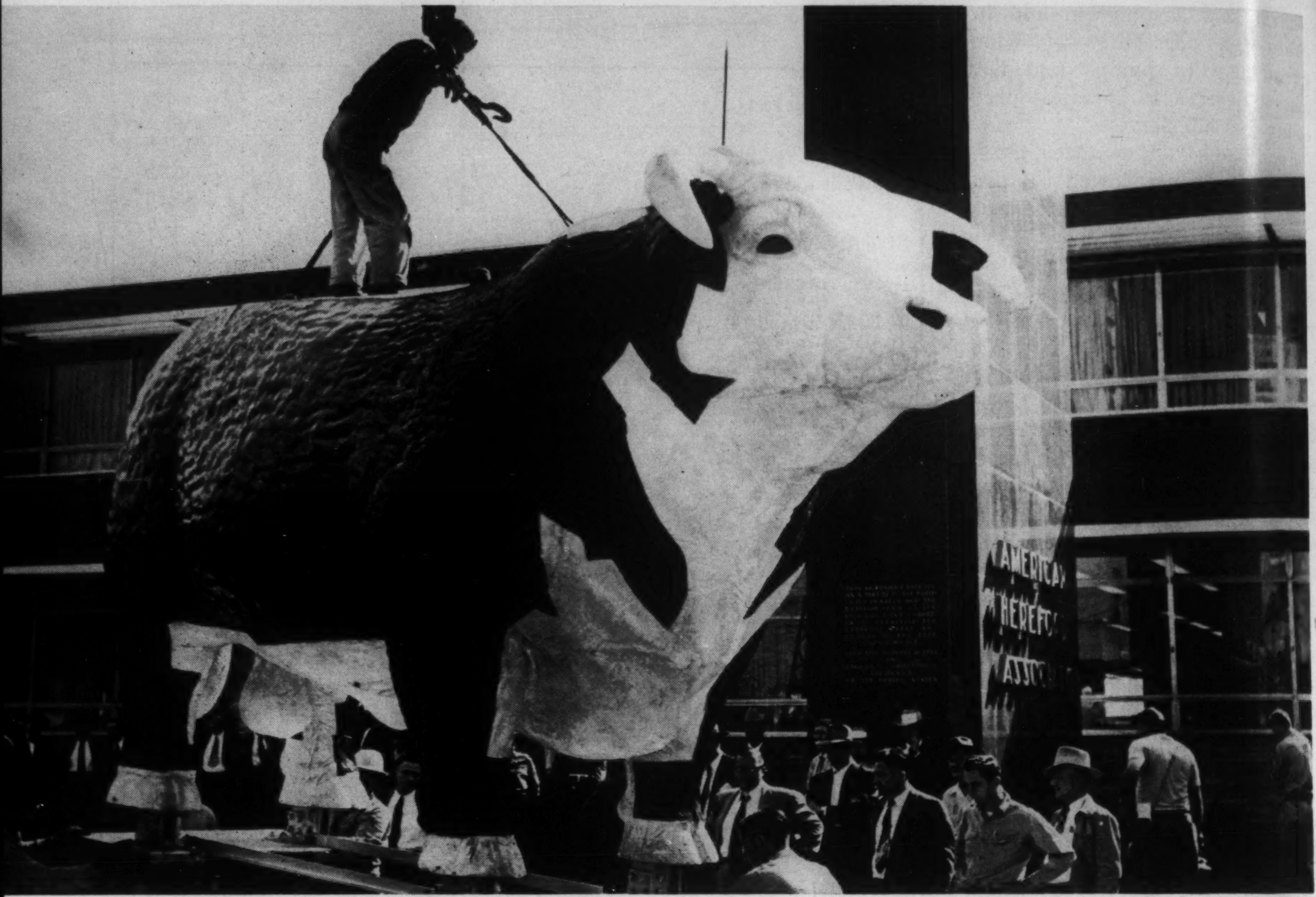
| Solution | Weight Losses (mg) | | Visible Change in Tin-Nickel |
|---|---|---|---|
| | Nickel | Tin-Nickel | |
| Concentrated hydrochloric acid | 54.1 | 127.0 | Uniform dull slate grey |
| Glacial acetic acid | 474.2 | nil | None |
| Sulfurous acid (0.4 gm per l So$_2$) | 41.4 | nil | Very slight darkening |
| Iodine in alcohol (5%) | 64.5 | 4.1 | Slight darkening |
| Bromine water (saturated) | 256.2 | 125.4 | Lightly etched |
| Sodium hypochlorite (40 gm per l available chlorine) | nil | nil | None |
| Hydrogen sulfide (saturated) | 20.3 | nil | None |

*Note: On 3- by 1-in. specimens exposed to corrosive vapors for 24 hr.*

*(Tin Research Institute)*

# Materials at Work

*New and old materials in unusual applications*

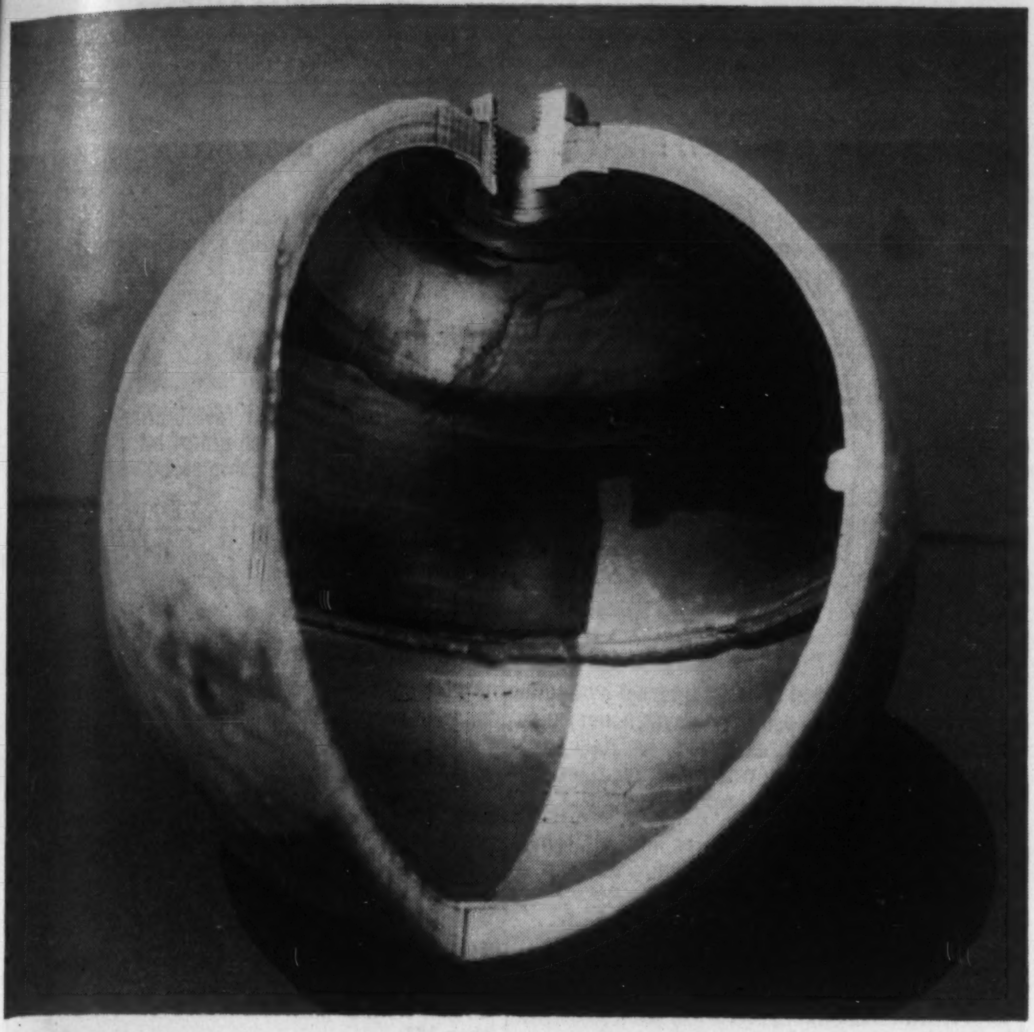


## Plastics Bull

Three times life-size, this bull made of glass-reinforced polyester, supported by steel I beams and held together by bolts and stainless steel sutures, is shown being erected atop a 90-ft pylon in front of the American Hereford Association's building in Kansas City. Plastics resin used is Paraplex 431, an ultra-violet resistant resin manufactured by Rohm & Haas Co.

The form is designed to withstand winds of over 110 mph, temperature extremes of −40 to 120 F and hailstones falling at terminal velocity. Test panels of the skin were subjected to ice cubes catapulted at speeds of over 100 mph. The bull is internally lighted by more than 700 ft of high-intensity cold cathode tubing in the form of 8-ft hairpin tubes, mounted on the framework. Prime contractor for the structure was Colonial Neon Co., while Colonial Plastics Corp. fabricated the skin.

*More Materials at Work on p. 111*



**Sectional view** *of prototype spherical pressure vessel.*

# Plastics Pressure Vessels

## **Are they feasible? . . .** *Preliminary studies indicate that they are. This report tells why and gives data on the performance of early prototypes.*

**by Milton A. Raun,**
*Chief, Materials Development Branch,*
*Chemical Corps Chemical & Radiological Laboratories*

■ Pressure vessels made of reinforced plastics have several advantages over those of metal:

1. For a given capacity, they can be made lighter without sacrificing other requirements.
2. They can be made in a greater variety of shapes to meet unique design or application requirements.
3. They are non-corrodable.

In addition, they offer a good combination of impact strength, dimensional stability and resistance to weather and temperature extremes.

Chief limitations at the present time are:

1. Without close control the heterogeneous nature of the material tends to raise difficulties that have adverse effects on the characteristics of the final product.
2. More specific engineering data on reinforced plastics are needed before the bases can be established for continuous, uniform production of vessels with desired characteristics.

These conclusions were reached as a result of a Chemical Corps development program that is still in progress. A preliminary study had shown that a reinforced plastics pressure vessel could offer significant advantages in a portable flame thrower; namely, the elimination of corrosion problems, better protection for the operator, and a potential reduction in weight. Furthermore, the properties of available materials seemed to make such a development technically feasible, and the existence of sufficient manufacturing facilities seemed to make procurement practicable. Under the current program, both spherical and cylindrical pressure vessels have been evaluated. However, most of the data presently available for publication were obtained for spherical pressure vessels.

### Spheres

Twenty-four spheres were obtained for evaluation. Design criteria for these spheres are listed in Table 1. The figure for "maximum weight" represents a 25% reduction in weight compared to a

TABLE 1—DESIGN CRITERIA FOR SPHERICAL PRESSURE VESSELS

| | |
|---|---|
| Capacity | 223 cu in. |
| Max diameter | 7-3/16 in. |
| Connections | One for 1-in. pipe |
| Operating pressure | 2000 psi |
| Test pressure | 3500 psi |
| Min burst pressure | 6000 psi |
| Max weight | 4.5 lb |
| Fragmentation | Resist shattering when pressurized and hit with .30 or .50 caliber bullets |
| Fatigue life | Withstand 200 cycles at 2500 psi |
| Heat resistance | Withstand 160 F when pressurized |
| Cold resistance | Withstand —40 F when pressurized |

conventional metal sphere of equal capacity. Criteria for all spheres were the same, except that three different sizes of thread openings were used for the pressure connection.

The spheres obtained averaged 193 cu in. capacity, 7¾ in. outside diameter, 4.45 lb weight and 43.2 cu in./lb capacity-weight ratio. They consisted of a thin (0.058 in.) aluminum liner covered by a relatively thick polyester-glass reinforced plastics shell. Thickness of the plastics shell varied from about ¼ in. in most sections to more than 9/16 in. at the pressure connection and opposite the pressure connection.

TABLE 2A—PROPERTIES OF REINFORCED PLASTICS SPHERES

| Test | Result |
|---|---|
| WATER ABSORPTION<br>Spheres immersed in water at 77 F for 48 hr. | 0.14% |
| POROSITY STRENGTH<br>24 spheres subjected to hydrostatic pressure of 3500 psi, then retested with air pressure of 2000 psi while immersed in water. | Five leaked at 200 psi, two at 200-500 psi. All leakage small, originating at junction of pressure connection and liner. |
| ULTIMATE BURSTING STRENGTH<br>Four spheres hydrostatically ruptured. | 7800-9000 psi |
| FRAGMENTATION<br>One sphere pneumatically ruptured (failed at 7800 psi). | Both plastics layer and metal liner badly torn and separated from each other, but no tendency for sphere to fragment completely. |
| VOLUMETRIC EXPANSION<br>One plastics sphere and three metal vessels air-pressurized to 2000, then 3500 psi, while submerged in water. | 2000 psi / 3500 psi<br>Plastics sphere 0.832% 1.593%<br>Aluminum sphere 0.319% 0.598%<br>Steel cylinder 0.256% 0.433%<br>Steel sphere 0.209% 0.376%<br>No permanent set in any vessel. |
| FATIGUE LIFE<br>One sphere subjected to cyclic internal hydraulic pressure of 0-2000 psi at 22 cycles per min. Another sphere air-pressurized to 2000 psi, dropped 6 ft on concrete without visible damage, then subjected to above fatigue test. | Both leaked from minute holes at 470 cycles and showed fatigue crack at weld joint of metal liner. |
| Two spheres immersed in water and subjected to cyclic internal hydraulic pressure of 0-2100 psi at 10 cycles per min. | First failed at 250 cycles; crack in liner near junction with spud flange. Permanent set 1.42% at 200 cycles. Second failed at 812 cycles; crack along circumferential weld of liner. Permanent set 10.8% at 300 cycles, 12.8% at 800 cycles. |
| Two spheres were subjected to same test (see above) with maximum pressure of 2600 psi | One failed at 154, other at 280 cycles—both in circumferential weld of liner. Permanent set less than 1%. |
| COLD STRENGTH<br>Unpressurized sphere held at —65 F for 48 hr, then (still cold) dropped 4 ft onto concrete. | No visible damage. |
| Above sphere filled with kerosene, held 24 hr at—40 F, then (still cold) hydrostatically ruptured. | Ultimate bursting pressure 10,250 psi—somewhat higher than for spheres ruptured at normal temperatures. |
| EFFECT OF CYCLIC TEMPERATURE CHANGE<br>Sphere air-pressurized to 200 psi, held one week each alternately at 165 F and —65 F for total of 28 days. | No significant increase in volumetric expansion, but leakage of about 300 psi starting in second week. |
| Above sphere ruptured hydrostatically at room temperature. | Failed at 7500 psi. |
| FRAGMENTATION BY GUN FIRE<br>Plastics sphere, steel cylinder and steel sphere, air-pressurized to 2100 psi, each were subjected to impact of one round of .50 caliber ball ammunition from 50 yd. | In plastics sphere, entrance hole was only slightly larger than bullet and exit hole was about 3 x ¾in. Fragmentation in both metal vessels. |

**Hydrostatically** *ruptured sphere (9000 psi).*

**Pneumatically** *ruptured sphere (7800 psi).*

**TABLE 2B—PROPERTIES OF REINFORCED PLASTICS CYLINDERS**

| Test | Result |
|---|---|
| PERMANENT SET<br>Two cylinders subjected to internal hydrostatic pressure of 3500 psi. | 9.25 and 1.96% |
| POROSITY STRENGTH<br>Above cylinders then air-pressurized to 2000 psi. | No leaks. |
| EFFECT OF DESERT STORAGE<br>One of above cylinders air-pressurized to 2000 psi, held at 160 F. | Ruptured near pressure connection end after 4 hr (this area had been machined down). |
| EFFECT OF CYCLIC TEMPERATURE CHANGE<br>Cylinder air-pressurized to 2000 psi, held one week at —65 F and one week at 125 F. | No defects after first wk. Slight parting of glass strands near pressure connection after second wk. |
| HOT STRENGTH<br>Unpressurized sphere held 24 hr at 125 F, then (still warm) ruptured hydrostatically. | Ultimate bursting pressure—7000 psi. |
| EFFECT OF DESERT STORAGE<br>Sphere air-pressurized to 2000 psi, held 28 days at 160 F, then pressurized to 3500 psi. | Almost 100% increase in vol ex from 2000 to 3500 psi. Permanent set 52%. No visible defects. |
| Above sphere ruptured hydrostatically at room temperature. | Failed at 8700 psi. |
| EFFECT OF TROPICAL STORAGE<br>Sphere air-pressurized to 2000 psi, held 28 days at 113 F and 85% R. H., then pressurized to 3500 psi. | No significant increase in volumetric expansion from 2000 to 3500 psi. No visible defects. |
| Above sphere ruptured hydrostatically at room temperature. | Failed at 8700 psi. |
| EFFECT OF ARCTIC STORAGE<br>Sphere air-pressurized to 2000 psi, held 28 days at —65 F, then pressurized to 3500 psi. | No significant increase in volumetric expansion from 2000 to 3500 psi. No visible defects. |
| Above sphere ruptured hydrostatically at room temperature. | Failed at 8500 psi. |
| Above cylinder then held at —65 F. | Leakage after 4 days both where glass parting previously observed and also near other end. |

The aluminum liner was made by welding together circumferentially two spun hemispheres of 3003-0 (3S-0). The pressure connection was made of 6061 (61S) and joined to the inner surface of the liner by an epoxy adhesive.

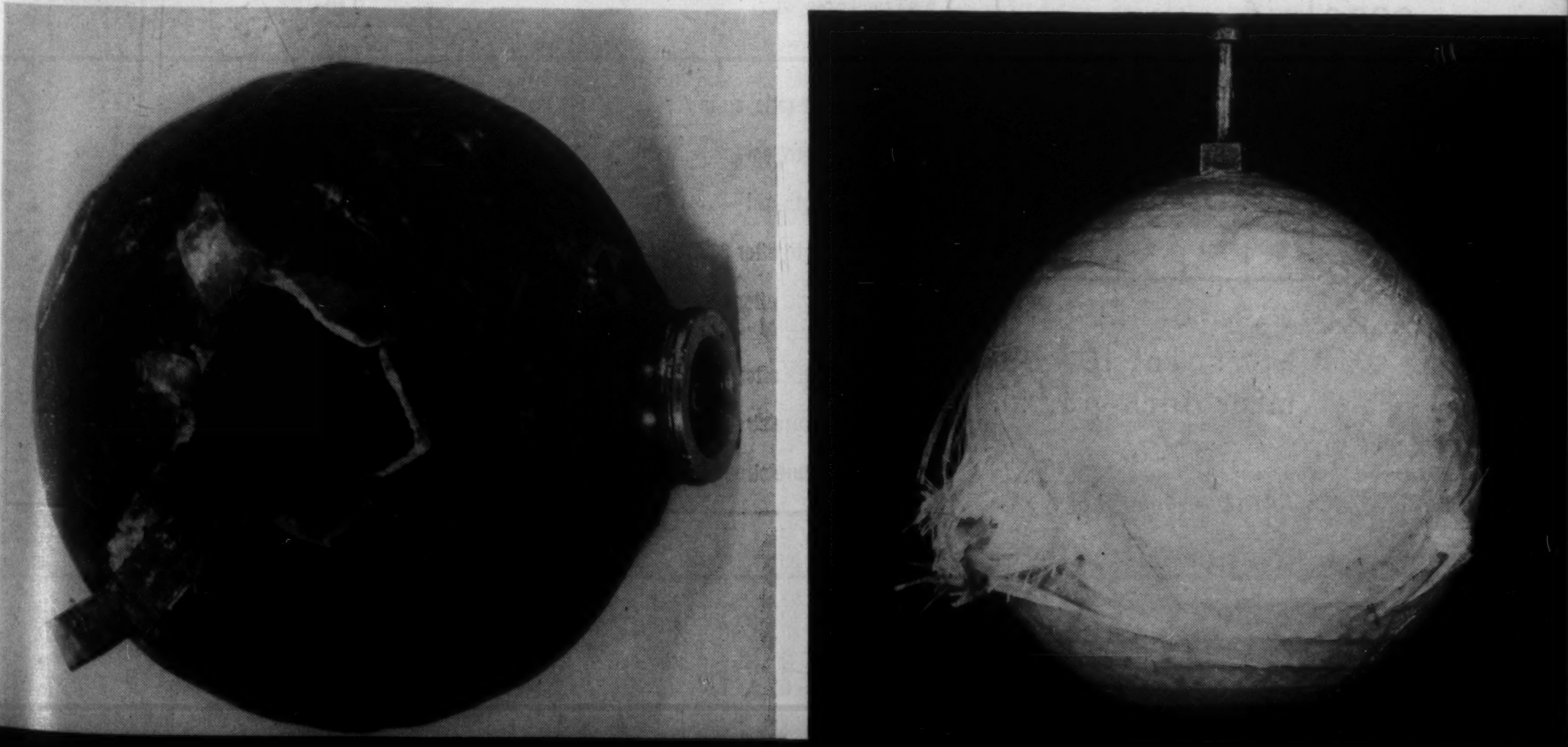
The plastics shell was formed by winding glass fiber strands (or roving) around the liner and impregnating the glass with polyester resin, the resin being applied by brush. Each glass roving consisted of 12 strands and each strand consisted of 204 filaments measuring 0.38-0.39 mils dia.

Properties of the spheres are in Table 2A. With the exception of "water absorption," not significant for metal, the evaluation procedures were the same used for conventional pressure vessels. Note the large increase in volume of the pressurized sphere after storage at 160 F. This greatly increased elasticity is probably due to thermoplasticity in the polyester resin formulation. Since this formulation can be varied, it is likely that this tendency toward excessive elasticity can be overcome.

Stress-strain behavior of one sphere which ruptured at 7200 psi was studied by means of strain gages. The slope of the stress-strain curve changed sharply at about 2000 psi, indicating a sudden increase in strain rate over a pressure increment of about 500 psi; the curve then changed sharply in the reverse direction, tending to resume its former slope. A similar phenomenon occurred at about 4000 psi. Others working on reinforced plastics pressure vessels have reported the same characteristic. One theory holds that any irregularities in the resin-fiber construction tend to adjust themselves as the outer cover assumes a true spherical shape under pressure, and that the sudden yielding reflects an accompanying redistribution of stress.

In all ruptured spheres, the fracture line was in the direction of the diagonals of the parallelograms formed by the criss-crossed roving, indicating that failures began at roving intersections. The high tensile strength (about 125,000 psi) of the glass fibers in the fracture areas makes it unlikely that failures resulted only from tensile or hoop stresses. Glass fibers have much lower shear strength than tensile strength, however; and the roving intersec-

*Firing a .50 caliber bullet into these spheres, both under about 2000 psi pressure, produced fragmentation in the metal sphere (left), no fragmentation in the plastics sphere (right).*



tions are probably subject to shear stresses from bending due to tangential or peripheral strain, as well as double shear stresses due to normal or radial strain.

**Cylinders**

Properties of two cylinders initially evaluated are also given in Table 2B. Design criteria for these cylinders were the same as for the spherical vessels. Unlike the aluminum-lined spheres, these cylinders had liners of modified epoxy resin. Such liners are claimed to provide a fatigue life of many thousand cycles, although no supporting data are yet available.

The first cylinders tested exhibited failures of the connection tube insert under hydrostatic pressure of 3400 psi; this deficiency has been largely corrected in more recent prototypes. Generally, the poor performance of some initial cylinders appeared to be due more to deficiencies in design than to shortcomings of materials. Location of the failures seemed to demonstrate that not enough design consideration had been given to the unique properties of reinforced plastics and to the need for uniform stress distribution.

Extensive work is currently being done on cylindrical pressure vessels. Among the factors being investigated are: use of parallel or angular-wound glass fibers or roving and/or glass mat or cloth; use of various plastics and metallic liners; use of metallic or other types of reinforcement instead of glass; and use of polyester, epoxy and other binding resins.

Properties of some more recently-designed reinforced plastics cylinders are given in Table 3. The low pressure cylinder was designed to operate at 450 psi with minimum fatigue life of 2000 cycles at that pressure and with a minimum rupture strength of 900 psi.

Although not entirely satisfactory, prototypes of both spheres and cylinders have exhibited most of the desired characteristics specified by the design criteria. However, it is clear that further development is necessary to realize to the utmost the inherent advantages of reinforced plastics.

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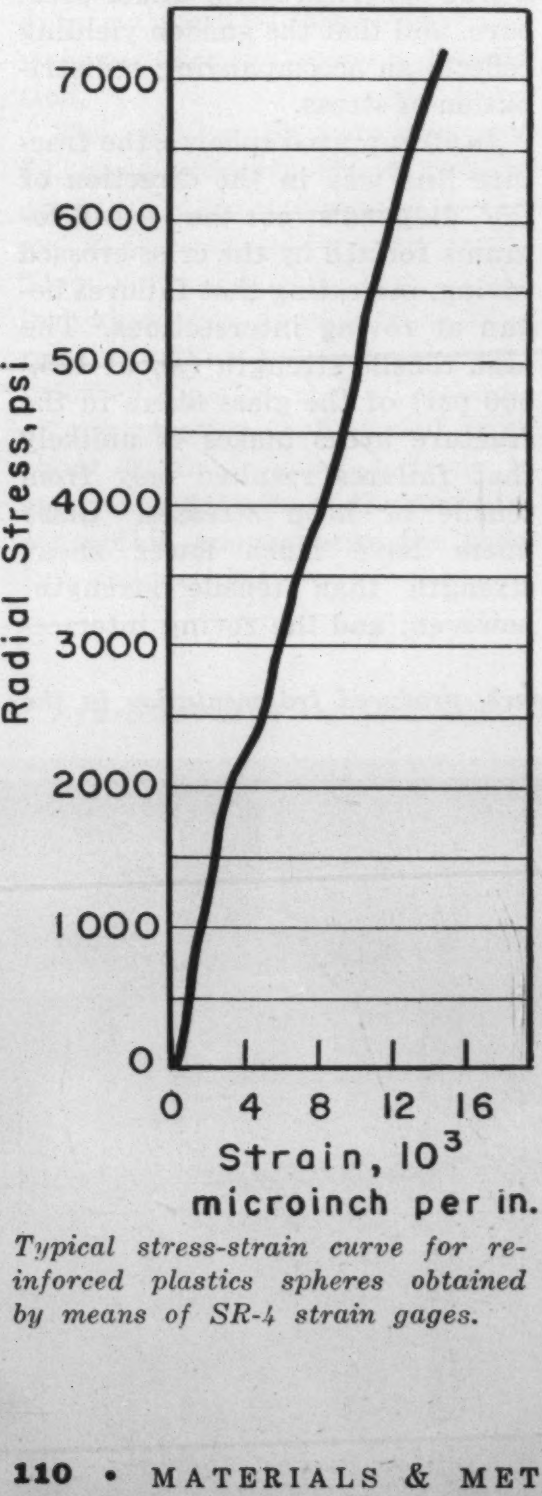
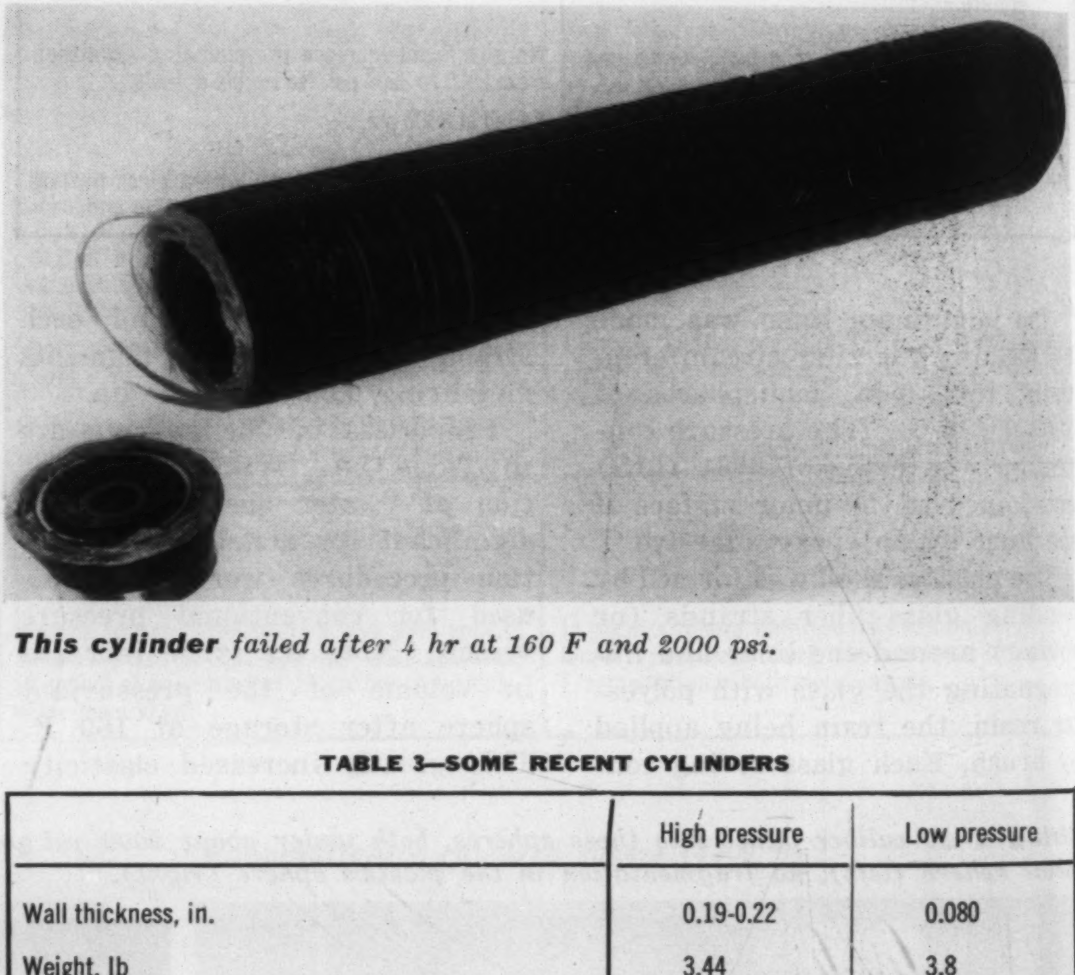
**This article is based upon a paper presented at the spring meeting of the American Society of Mechanical Engineers in Baltimore, Apr. 1955.**



*Typical stress-strain curve for reinforced plastics spheres obtained by means of SR-4 strain gages.*



***This cylinder** failed after 4 hr at 160 F and 2000 psi.*

**TABLE 3—SOME RECENT CYLINDERS**

| | High pressure | Low pressure |
|---|---|---|
| Wall thickness, in. | 0.19-0.22 | 0.080 |
| Weight, lb | 3.44 | 3.8 |
| Volume-weight ratio, cu in./lb | 57.6 | 151.7 |
| Rupture strength, psi | 6000 (min) | 900-950 |
| Porosity strength, psi | 5200-5500 | 750-850 |
| Rupture strength after 2000 cycles at 2500 psi, psi | 5200 | — |
| Porosity strength after above cycling plus 3500 psi test, psi | 4200 | — |
| Rupture strength after 2000 cycles at 450 psi, psi | — | 950 |
| Change in rupture strength at 160 F | About 10% drop | About 10% drop |
| Change in rupture strength at —40 F | None | None |

## Materials at Work

*New and old materials in unusual applications*

### An Aluminum First?

Aluminum heat exchanger tubes are shown being installed in a new 105,000 sq ft Allis-Chalmers surface condenser built for the Wisconsin Electric Power Co. It is believed to be the first such unit to be fitted with aluminum heat exchanger tubing.

### Plastics Drop Hammer Dies

Lower cost drop hammer dies are being produced by Republic Aviation Corp. by casting an epoxy resin face on kirksite. Surface of female member is made of straight epoxy resin while punch face consists of resilient mixture of epoxy and Thiokol, a polysulfide liquid polymer produced by Thiokol Chemical Corp. Dies are used to produce aluminum and stainless steel aircraft parts. A production die is at left; below, a part formed by die is removed from drop hammer.

# 6 Ways Wire Thread Inserts Improve Fastener Performance

*By protecting and reinforcing threads, stainless steel wire thread inserts solve many fastening problems.*

**by P. E. Wolfe and A. H. Mussgnug,** *Heli-Coil Corp.*

■ One of the most common problems encountered by engineers in developing or redesigning assembled products is determining the most effective fastening methods. Improperly designed threaded fastenings frequently prevent optimum application of new materials or designs.

Wire thread inserts are today used to solve many fastening problems. Coiled from 18:8 stainless steel wire of diamond cross-section, these inserts are manufactured to standard thread specifications.

### Types and uses

Standard wire thread inserts are made of AMS 7245 stainless steel and AMS 7247 phosphor bronze. The bronze inserts are used to provide electrical contact in various types of boss materials. Precision manufactured to provide internal nominal size threads, the inserts can be used interchangeably to provide any thread fit—Classes 3, 3B, 2 or 2B. When assembled in a hole tapped with a Heli-Coil tap, they form threads conforming to National Bureau of Standards Handbook No. H 28, "Screw Thread Standards for Federal Services," published in 1944, and its later supplements.

They are available in the following standard sizes and thread classifications:

a. 4-40 to 1½-6 sizes in National and Unified Coarse Thread Series

b. 6-40 to 1½-12 in the National and Unified Fine Thread Series

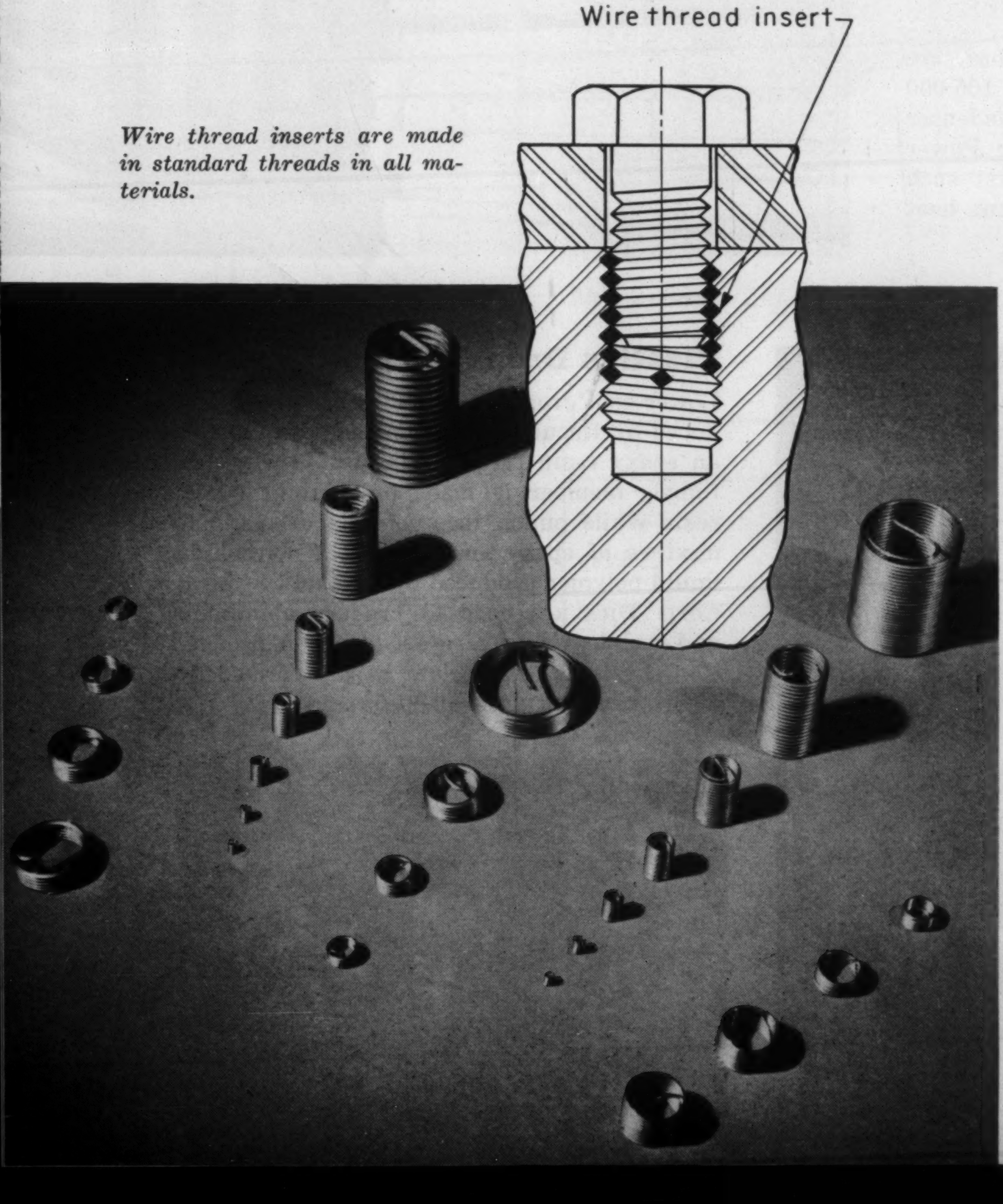
c. 10-1.0 mm to ⅞-18 in the Automotive Spark Plug Series

d. 14-1.25 mm to 18-1.5 mm in the Aviation Spark Plug Series

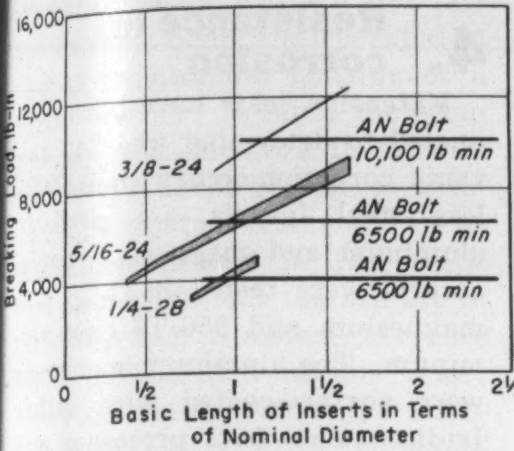
e. ⅛-27 to 1-11½ in the Pipe Thread Series

Groups (a) and (b) are supplied in standard 1-, 1½-, 2-, 2½- and 3-dia lengths. Military standards have been issued for groups (a) and (b); groups (c), (d) and (e) conform to military requirements. Non-standard lengths and sizes can be supplied for special applications.

The recently developed screw-lock insert has all the qualities of the conventional wire thread insert and is able, by virtue of its conformation, to lock the engag-



*Wire thread inserts are made in standard threads in all materials.*



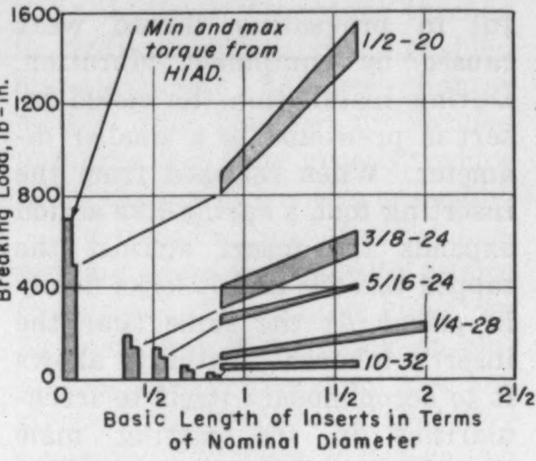
*Tensile results on insert-protected threads in C-T6 cast magnesium.*

ing screw in place positively without the need for lock nuts or washers. Currently manufactured in 6-32, 8-32, 10-24, 10-32, ¼-20 and ¼-28 sizes in two lengths, screw-lock inserts will soon be provided in other standard thread sizes. These inserts meet military specifications for lock nuts.

## 1. Higher loading strength

Wire thread inserts provide higher loading strengths than standard tapped threads in the same material. Because they are flexible, the inserts adapt themselves readily to the receiving threads of the tapped hole, thus compensating for angle and lead error. The resulting increased thread flank engagement distributes the load over the entire threaded assembly.

Increased strength in both tensile and torque is produced in the tapped hole. Insert-protected threads averaged from 10-25% stronger in tension and 15-30% stronger under torque than standard tapped threads in tests conducted with standard AN bolts and 2024 or 2017 ST aluminum. Moreover, while stripped threads often represented the failure in the standard unprotected holes, bolt failure often occurred first in specimens protected by inserts. A comparison of the tensile strength of insert-protected threads against that of standard threads for 10-32 size tapped in 2024S-T4 aluminum, shows that the protected threads are stronger in every case. Average increased strength attributable to the insert is 21%.

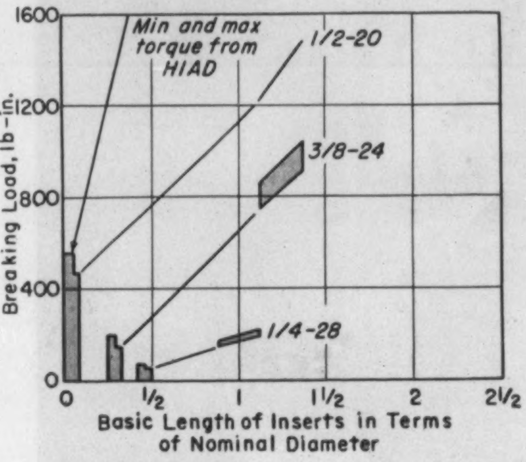


*Torsion test results on insert-protected 356-T6 cast magnesium.*

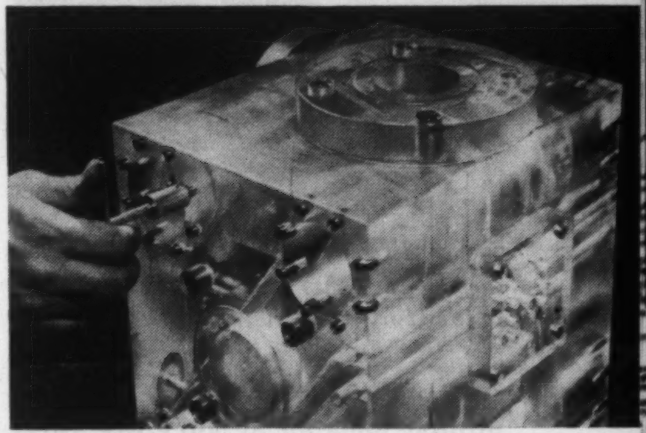
An accompanying curve illustrates the ability of inserts of various sizes to develop thread tensile strength in C-T6 magnesium. Tensile load at failure of the threads is plotted against insert length in diameters. The horizontal lines indicate the minimum tensile strength required of AN bolts (125,000 psi min ultimate tensile strength) of the specified size. It can be seen that the inserts develop the minimum tensile strength of the bolt with less than 1½ diameter of insert length engaged.

Other curves show the results of torque test conducted with inserts of various sizes and lengths in 356-T6 cast aluminum and C-T6 cast magnesium. It can be seen that the installation torque at which the insert-protected threads fail exceeds the maximum "installation torque" recommended by the Handbook of Instructions for Aircraft Designers, represented by the vertical columns at the lower left. For example, with inserts one diameter long, the torque at failure can be from 1 to 2 times as high as the recommended maximums, and from two to three times as high at 1½ diameter engagement.

Although wire thread inserts are most commonly used in aluminum and magnesium, primarily in the aircraft industry, they have been effective in providing additional thread strength in many other engineering materials. For example, installed in the acrylic flow valve of a water conditioner, inserts almost double the strength of the plastic threads. Threads tapped in the plastic valve could not withstand tests at required pressures up to 200 psi —exerting a 320-lb tensile load on each screw. Installation of 124 inserts in this 4-in. valve strengthened it sufficiently to sustain test pressures with no failure.



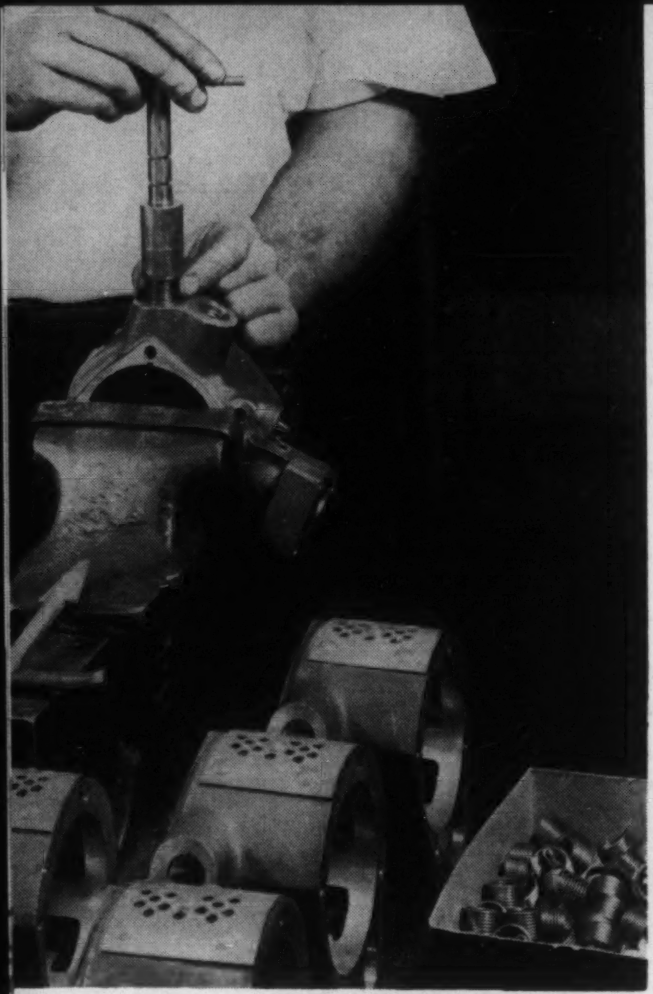
*Torsion test results on insert-protected C-T6 cast magnesium.*



*Steel inserts in acrylic valve strengthen plastics threads to withstand 320-lb tensile load.*

## 2. Resistance to frictional wear

Metal is rolled to form the inserts; therefore, they have a much smoother surface than standard threads which are cut from the metal. Because they have a hardness of 43-50 Rockwell C and a surface finish of 8 to 15 microinches, they are less susceptible to wear themselves and cause less frictional wear at mating surfaces than do tapped threads. As a result, inserts have proved valuable in assemblies which must be disassembled periodically for inspection.



*Wear life of the magnesium dead handle of this rotor tool was increased by using wire thread inserts.*

The threaded holes in the aluminum housing of an x-ray tube once were often damaged during field maintenance operations, so that many housings had to be returned periodically to the factory for repair. By protecting every tapped hole in the three-piece housing with a 10-32 wire thread insert, the time and labor required for the manufacturer to inspect and repair units with damaged threads are eliminated.

The dead handle of a portable air tool is removable and can be used in either of two positions depending on the operator's preference. Threads tapped into the tool's magnesium body casting to hold the dead handle did not wear satisfactorily. The threads were often stripped in the process of removing and replacing the handle. Installation of ⅝-18 wire thread inserts in the two tapped holes which receive the handle solved the problem and materially improved customer relations.

## 3. Resistance to vibration wear

Because the insert locks itself in the hole tapped to accommodate them, wire thread inserts are useful in preventing thread wear caused by equipment vibration. During installation the coiled insert is prewound to a smaller diameter. When released from the inserting tool, a spring-like action expands the insert against the tapped threads and it locks firmly in place. At the same time the insert's inherent flexibility allows it to accommodate itself to irregularities in the mating male threads so that no movement occurs between threaded components.

Thread inserts, for example, provide excellent threads in a crown finishing hat machine because of their ability to resist wear due to vibration. The abrasive pad of this machine oscillates at the rate of 6800 strokes per min. The sponge rubber pad is fastened to a magnesium pad frame by means of eight 6-32 screws. Installation of wire thread inserts has not only strengthened the threads in the magnesium, but also has protected these threads and the mating screw threads from vibration wear. Magnesium was used for the pad frame in order to minimize the inertia of this rapidly oscillating assembly.

Protection of threads from vibration wear was also a factor in the specification of wire thread inserts in a portable air tool. With parts rotating at speeds up to 6000 rpm, these tools are subject to considerable vibration. The inserts eliminated thread wear caused by vibration as well as friction.

## 4. Resistance to corrosion

Extensive tests have been conducted to determine whether galvanic corrosion occurs when stainless steel inserts are used in aluminum and magnesium parts. Inserts were tested in C-T6 cast magnesium and 356-T6 cast aluminum. The aluminum specimens were surface-coated with either Iridite 14 or 14-2 processes and the magnesium with Iridite 15 or Dow 7 processes. AN bolts were torqued according to USAF instructions and lacquered as prescribed by military specifications. The magnesium specimens were subjected to 200-hr salt spray and the aluminum to 500 hr. No galvanic corrosion occurred in any portion of any of the assemblies, whether in a blind or through hole and regardless of whether the surface coatings were applied before or after insert installation. In addition, there was no sign of corrosion on the insert.

Resistance of inserts to atmos-

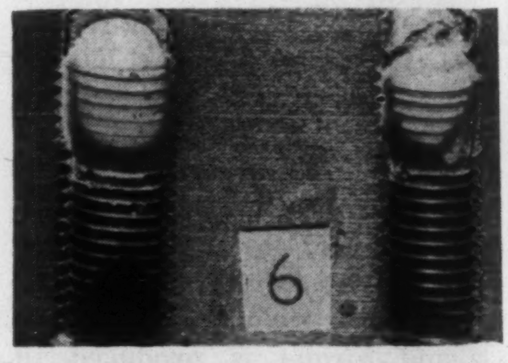
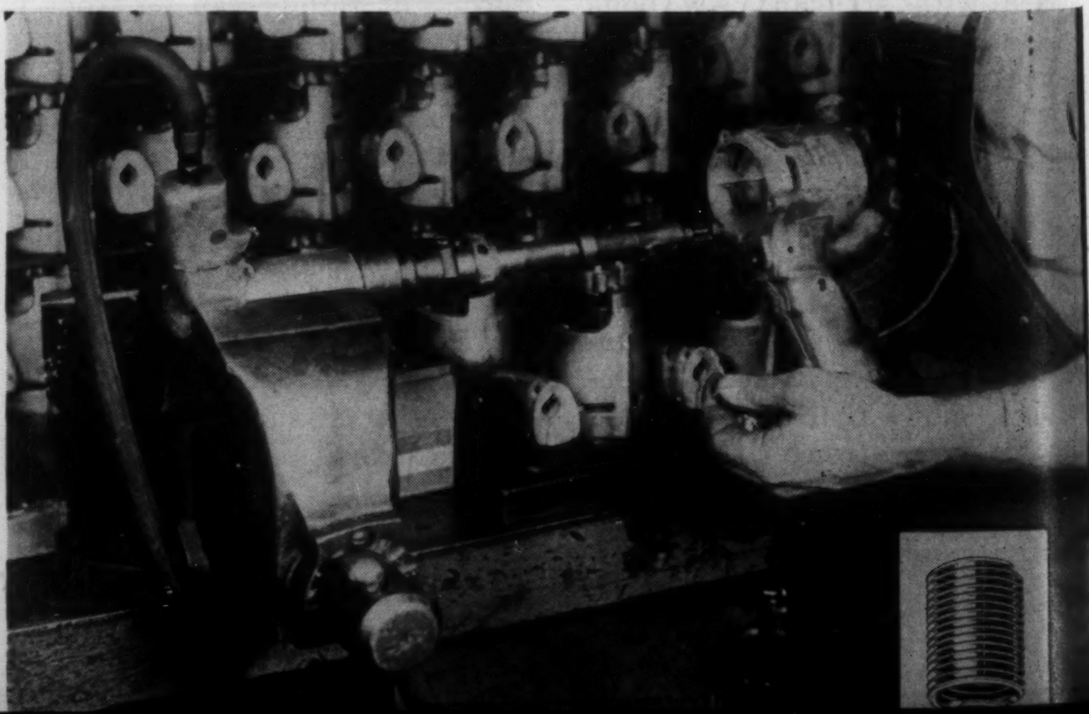


*Photo demonstrates fact that galvanic corrosion did not occur between insert and base material.*

*Inserts used in body of air tool eliminated thread wear caused by vibration.*



pheric corrosion was a major factor in their being incorporated in the cast aluminum housing of a radar scanner. Because the scanner is used outdoors in various climates, it must be able to withstand alternate freezing and thawing temperatures in the arctic and sub-arctic and the sea air of coastal areas. Standard threaded holes deteriorated rapidly under these conditions, while the stainless steel inserts completely eliminated this corrosion problem.

## 5. Resistance to galling and seizing

The hard, dense, smooth surface of the stainless steel thread inserts render them immune to seizing and galling. This is not the case with the cut metal surfaces of a tapped hole. Standard stainless steel inserts can withstand temperatures up to 800 F without ill effects and offer a solution to problems of seizing caused by exposure to high temperatures.

Inserts have been used in such devices as induction furnaces, tire molds, and glass molds to eliminate galling and seizing which previously occurred as a result of the high temperatures.

## 6. Save space and weight

Two ways to reduce space and weight requirements are provided by the use of inserts. Having no wall thickness, they are smaller in diameter than solid bushings and require less space for installation. Inserts can be installed in a boss of the same diameter required by standard tapped threads of the same size. In addition, their ability to strengthen threads in soft materials has enabled manufacturers to use lighter metals and plastics in various products and thus greatly reduce the weight of the entire assembly.

The manufacturer of resistance-welding guns was able to reduce the weight of a portable gun from 33 lb to 11¼ lb by using an aluminum alloy. However, the low strength of threads in the alloy presented a problem in design. An extremely tight connection was required between the aluminum gun yoke and a copper jumper to prevent the formation of insulating oxides between the two parts, which must permit the passage of currents in the range of 5,000 to 10,000 amp. Threads tapped into the alloy could not withstand the high torques applied to the bolts which fastened the jumper to the yoke. Stainless steel thread inserts strengthened these threads sufficiently to permit the use of the aluminum alloy in the gun, which has received wide acceptance in the automotive industry because its lightness substantially reduces operator fatigue.

Lightweight plastics have replaced metal in the design of many jigs and fixtures in order to reduce their weight. Welding fixtures of glass fiber epoxy laminate were more desirable than metal ones in the fabrication of jet engine parts because of their light weight and better surface wear characteristics. Wire thread inserts were specified to provide strong, durable threads at certain joints to withstand frequent removal and replacement of screws.

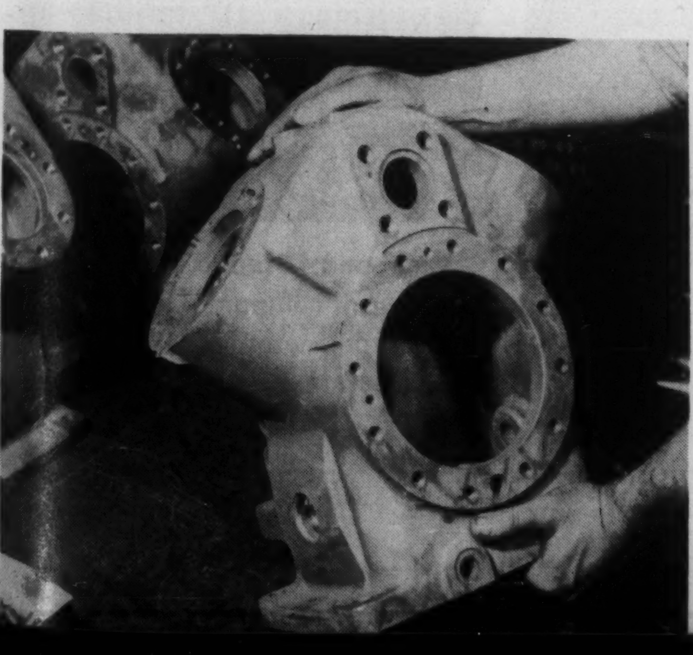
A manufacturer of air conditioners was able to reduce the weight of equipment used in busses, trucks, aircraft and ships by making the compressor housing of aluminum rather than cast iron. Sixty-six wire thread inserts gave the threads tapped into the aluminum casting 40% more strength than they had when unprotected, and provided a tight gas seal. The small diameter of the coiled insert as compared to solid bushings allowed the producer to use the original casting design formerly made in iron to produce the new aluminum housing. Power installation of these 66 inserts provides an assembly rate compatible with other operations, and no radical change in assembly methods was required.

### *How to Install Inserts*

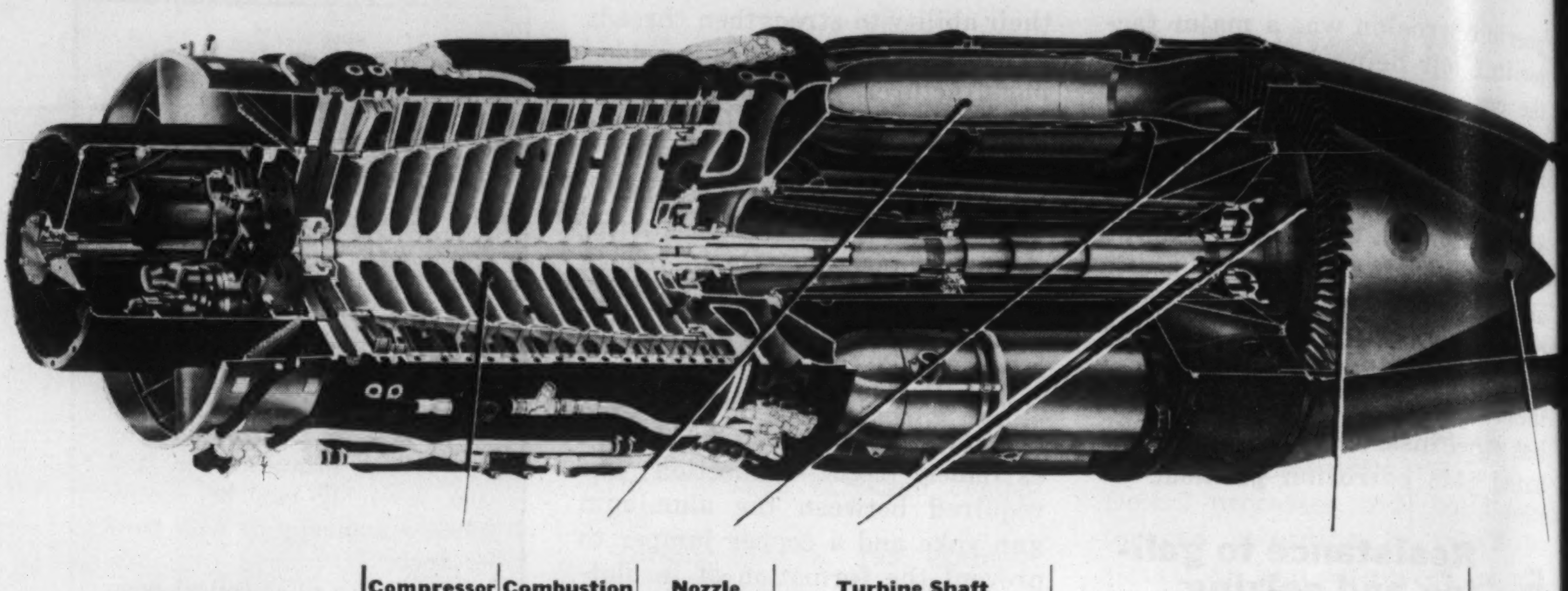
The installation of wire thread inserts is quite simple. requiring only drilling and tapping to prepare the hole to receive the insert. The class of fit is determined by the tolerances to which the hole is tapped. Taps, gages and inserting tools are supplied by the insert manufacturer, and the assembly can be accomplished manually or with power tools.

Both air and electrical power tools can be adapted to install inserts on a production basis. Tools installing as many as six inserts at the same time are in use. The insert manufacturer will assist users in the development of tools, jigs and fixtures required to install the inserts to meet specific production requirements.

Drilling and tapping procedures follow standard shop practice. The inserting tool prewinds the insert and screws it into the specially tapped hole by applying torque to a diametral tang. If removal of the tang is required after installation, as in through-holes or spark plug applications, inserts with notched tangs should be used. These notched tangs break off cleanly and are easily removed from the assembly.



*With the help of inserts to strengthen holes, this compressor housing is now made of aluminum and weighs considerably less than when formerly made of cast iron.*



| COMPONENT | Compressor Blades | Combustion Chamber Liners | Nozzle Partitions | Turbine Shaft and Wheel | | Turbine Buckets | | | Tailcone |
|---|---|---|---|---|---|---|---|---|---|
| **MATERIAL** | Type 403 (410) (RC 20-26) | Inconel Annealed | Vitallium (HS21) Cast | AISI 4340 | 16-25-6 | S-816 | M-252[8] | M-252[9] | Type 321 Annealed |
| **TEMPERATURE** | At 500 F | At 1500 F | At 1500 F | At 400 F[3] | At 1200 F[4] | At 1500 F[5] | At 1500 F[7] | At 1500 F[7] | At 1400 F |
| 1000 hr Rupture Str, psi | 78,000[1] | 3500 | 17,000 | 120,000 | 35,000 | 17,000 | 19,000 | 21,000 | 7000 |
| Fatigue Str, $10^8$ cycles | 97,000[2] | 15,000 | 28,000 | 70,000[2] | 37,000 | 38,000 | 46,500 | 53,000 | — |
| Tensile Str, psi | 105,000 | 21,000 | 60,000 | 134,000 | 80,000 | 95,000[6] | 140,000[6] | 155,000[6] | 32,500 |
| Yield Str, 0.02% offset, psi | 88,000 | 11,000 | 28,500 | 99,000 | 55,000 | — | — | — | 19,000 |
| Elongation, % | 17 | 75 | 30 | 16 | 27 | 35[6] | 8[6] | 12[6] | 50 |
| Reduction of Area, % | 66 | — | 25 | — | — | 35[6] | 10[6] | 14[6] | — |

[1] *At 800 F*

[2] *At room temperature*

[3] *Oil quenched from 1550 F; tempered at 1175 F*

[4] *Cold worked; 1200 F—2 hr—A.C.*

[5] *2150 F—1 hr—W.Q.; 1400 F—12 hr—A.C.*

[6] *At 1350 F*

[7] *1950 F—4 hr—A.C.; 1400 F—15 hr—A.C.*

[8] *Air melt*

[9] *Vacuum melt*

*Data taken from General Electric tests*

# Which Alloys for Jet Hot Spots?

*Though the parts discussed here do not make up an entire jet engine, they typify some of the problems of selecting materials to meet tough, critical service conditions.*

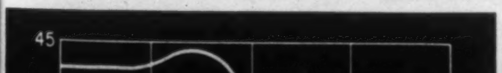
**by S. G. Demirjian,** *General Electric Co.*

■ Critical temperatures and stresses present imposing problems in selecting materials for components which must operate in six critical areas of the axial flow jet engine. These areas are 1) compression area, where air from the intake is compressed prior to mixing with fuel; 2) combustion area, where the air-fuel mixture is burned; 3) nozzle area, where hot gases resulting from combustion are guided to the turbine; 4) turbine area, where the hot gases spin the turbine and shaft which, in turn, turns the compressor wheels; and 5) tailcone area, where hot gases from the turbine are expelled.

### Compressor blades

Since development of the axial-flow type compressor, type 403 stainless steel has been the stand-rd production alloy for compres- or blades. Under normal condi- ions the blades in a typical en- ine operate at temperatures of bout 100 to 500 F. In this tem- erature range type 403 has ac- eptable properties in respect to amping, fatigue strength and orrosion resistance. The most roductive fabrication technique as been die forging. The only ubsequent operations required re broaching the dovetail, grind- ng leading and trailing edges, nd cutting off the tip.

Recently the hardness level of G-E's blades was reduced from Rc 32-38 to 20-26. This was done o increase damping capacity, hough it meant a decrease in atigue strength since fatigue trength of type 403 decreases ith decreasing hardness. Lowering the hardness range also reduced the possibility of stress-corrosion cracking, as well as providing somewhat increased corrosion resistance. To obtain the previous hardness of Rc 32-38, blades had to be tempered at around 1000 F, producing a finely divided precipitate which lowered corrosion resistance. Reducing the hardness level not only resulted in better quality blades, but simplified heat treatment, since Rc 20-26 is easier to obtain at a tempering temperature of around 1150 F where the hardness curve is flatter than at 1000 F (see accompanying curve of hardness vs tempering temperature).



*Note flattening of curve around 1150 F as compared with 1000 F, making it easier to obtain a hardness range of Rc 20-26.*

### Combustion chambers

The inner liners of combustion chambers are subjected to temperatures ranging from 1200-1800 F due to burning gases. The gases are under pressure and expand rapidly, and together with the cooling air, cause a temperature gradient and pressure unbalance which are great enough at times to cause distortion and buckling. Louvers, properly spaced in the liners, provide air cooling to distribute the temperature evenly over the liner surface.

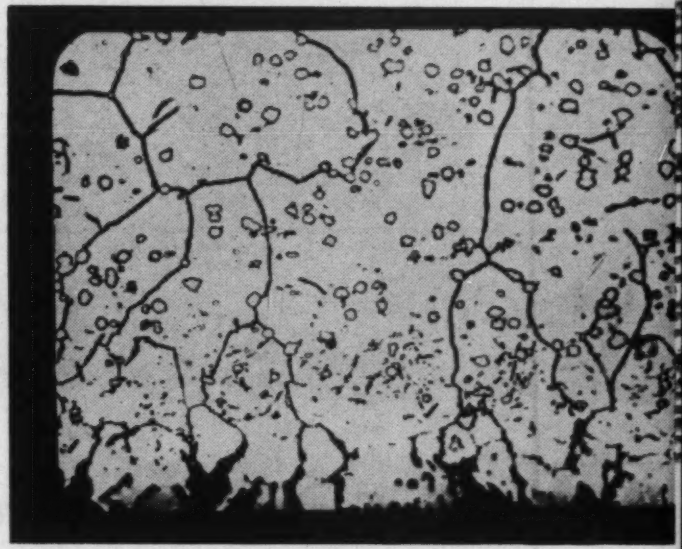
Sheet metal used for liners must have good formability, hot ductility, weldability and oxidation resistance. Inconel is satisfactory under current service conditions. As future operating temperatures mount higher, another material will have to be found; or perhaps ceramic coatings will permit use of the same material at higher temperatures.

### Nozzle area

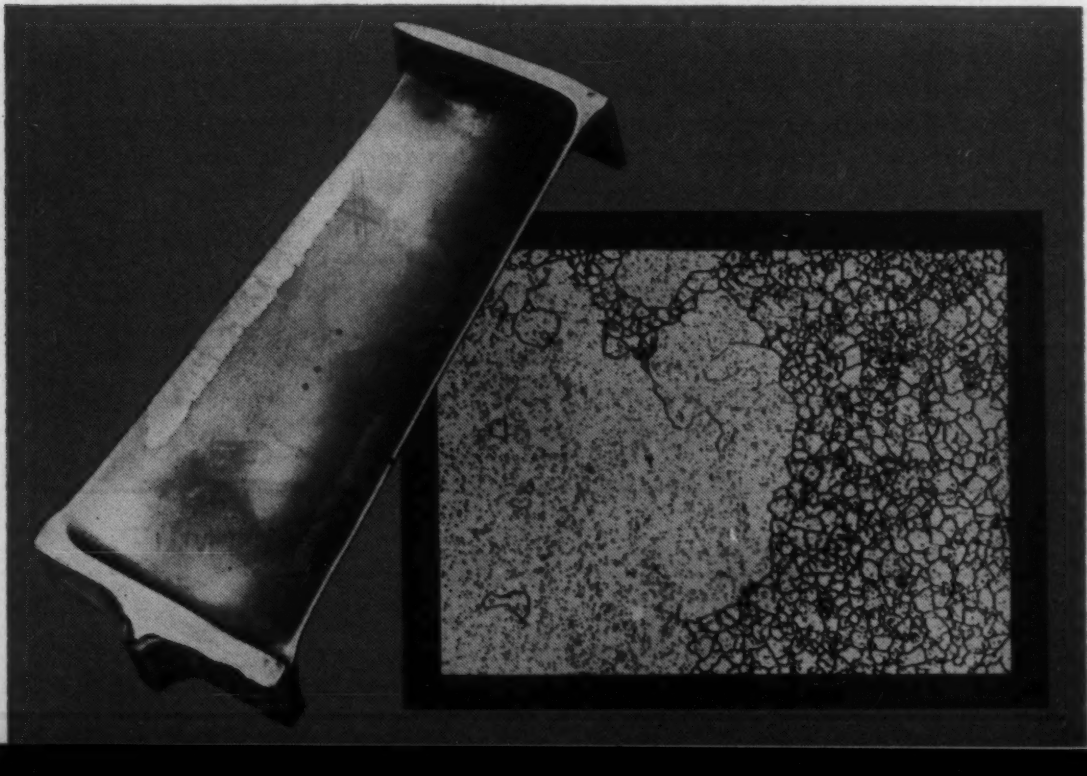
In leaving the combustion chambers the hot gases pass through nozzles to the turbine. The nozzle partitions are cast hollow of vitallium (HS 21), a cobalt base alloy with the following nominal composition: 0.25 carbon, 27 chromium, 3 nickel, 6 molybdenum, 1.5% iron and balance cobalt. These partitions are welded to pre-punched inner and outer bands of type 321 stainless steel. Major requirement for nozzle partition materials is good resistance to thermal shock. Some engine designs make use of a pre-turbine injection of a water-alcohol mixture which at times creates a cyclical quenching action on the nozzles. Also, when combustion systems are not operating properly, nozzle partitions can be exposed to wide temperature gradients. Such a condition results in high stresses which could produce distortion or cracking. Good high temperature strength and ductility in the material are necessary for successful operation under these conditions.

Vitallium castings are of fairly uniform grain size but grains are very coarse by wrought material standards. Coarse grain size may be beneficial since most failures

**Photomicrograph shows** *typical intergranular attack in M-252 induced by high forging and heat-treat temperatures.*



**Differential grain size** *in S-816 turbine bucket produced by lack of proper control of temperature during forging.*



are intergranular and coarse-grained materials, having less grain boundary, are less prone to intergranular failure.

**Turbine area**

The turbine wheel consists of a shaft and hub to which is welded a rim. Shaft and hub is an integral forging of heat treatable AISI 4340, and the rim is forged of an austenitic alloy 16-25-6 (nominal composition: 0.10 carbon, 16 chromium, 25 nickel, 6 molybdenum and 0.15% nitrogen). Operating temperature range for the turbine is about 400 F at the hub to 1200 F at the rim.

Seated in the rim of the wheel are turbine buckets which operate in the 1500 F temperature range. They have pinpointed the need for materials which will operate at ever increasing temperatures with higher stress-rupture strength, tensile strength, fatigue strength, thermal shock resistance and oxidation resistance. Early buckets were forged of Hastelloy B which has fair high temperature properties but is noticeably poor in oxidation resistance.

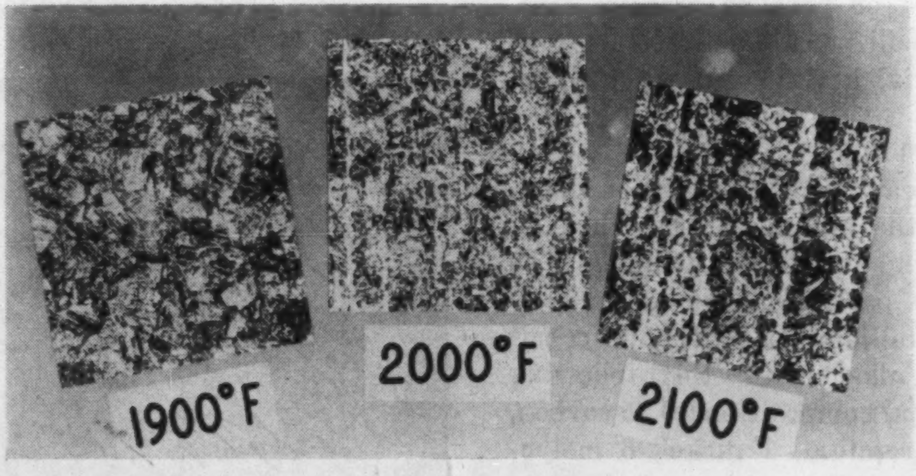
With the development of the axial flow jet engine, Allegheny-Ludlum's cobalt-base alloy S-816 has become a somewhat standard bucket alloy. Its nominal composition is 20 chromium, 20 nickel, 42 cobalt, 4 tungsten, 4 molybdenum, 4 columbium, 4 iron, 0.40% carbon. It is a solution-hardening alloy most widely used in the 1200-1500 F temperature range. It has outstanding corrosion resistance and excellent high temperature fatigue and stress-rupture strength. It must be forged at closely controlled temperatures as it is susceptible to formation of a differential grain size. To produce buckets of uniform grain size, high finish forging temperature on dies and low solution treating temperature must be maintained.

More recently G-E's nickel-base M-252 alloy has been gaining prominence as a bucket alloy. It is a titanium age-hardenable alloy with a nominal composition of 19 chromium, 10 cobalt, 10 molybdenum, 2.5 titanium, 0.75 aluminum, 4 iron, 0.15% carbon, balance nickel. Stress-rupture strengh of M-252 is slightly superior to that of S-816 at temperatures up to about 1500 F. At higher temperatures the reverse is true. Fatigue and tensile strengths of M-252 at elevated temperatures are superior to those of S-816. Forging temperatures for M-252 buckets must be maintained within a narrower range than for S-816 because of the strong tendency of this type alloy for grain germination.

Nickel-base alloys are susceptible to a superficial surface intergranular attack to a depth of approximately 0.002 in. at the high temperatures employed for forging and heat treating. This surface is removed by an electrolytic acid pickle operation. Also, finish grinding operations are severe enough to induce cold work, which could result in a layer of recrystallized metal when the buckets are exposed to engine operating temperatures. This cold-worked surface is also removed by an electrolytic acid pickle.

**Tailcone area**

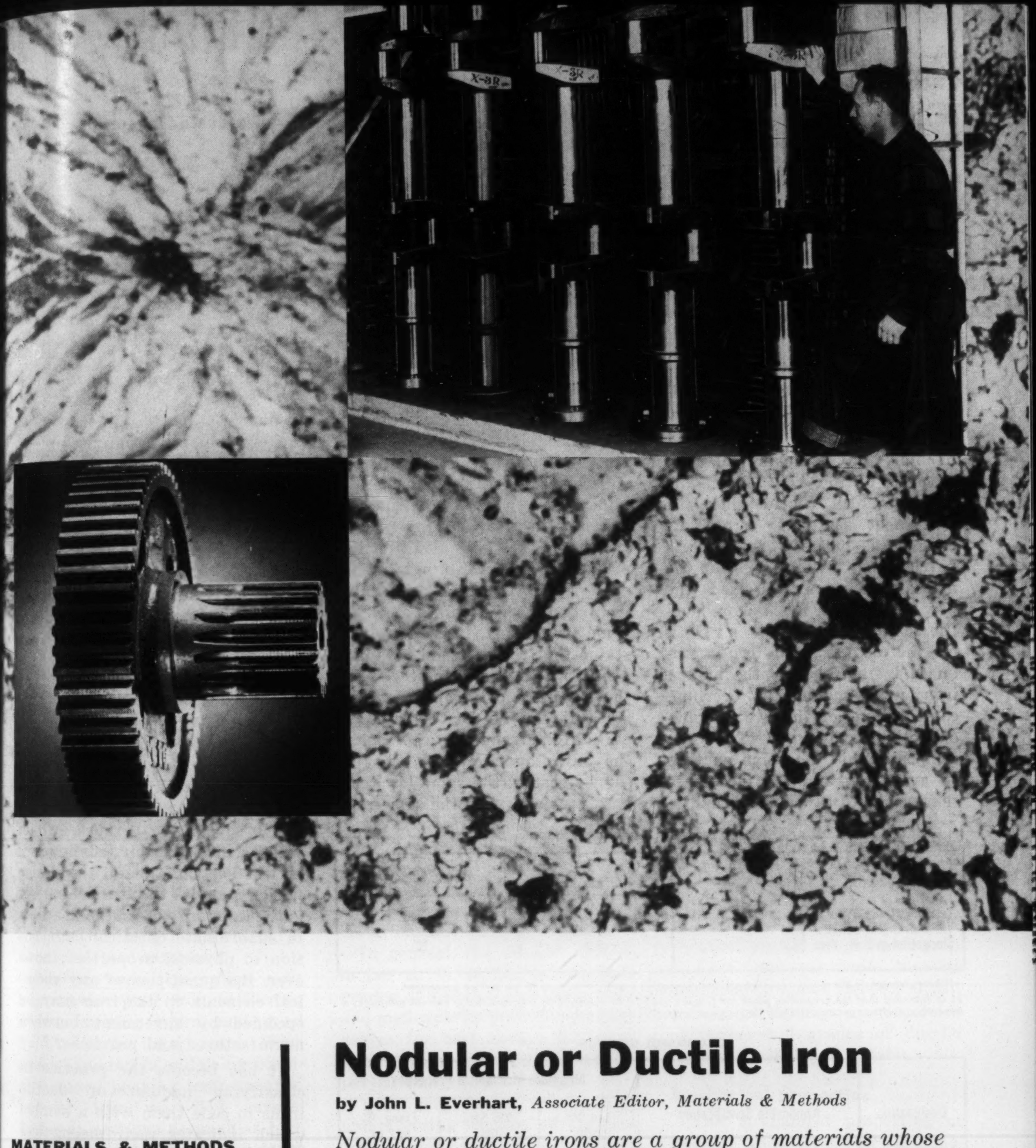
Tailcone temperatures range from 1000 to 1400 F. Problems in the tailcone are minor compared to those in other areas; however, under abnormal operating conditions, temperature gradients or hot spots can exist. A welded assembly of type 321 stainless steel has been found to perform most satisfactorily.



*Typical problem in materials development*

*A problem typical of those often encountered in engineering a material for a specific use was encountered at G-E in gaining the proper structure of type 403 steel for forged compressor blades. Structure in the annealed condition has a marked influence on the forgeability of type 403. A study of longitudinal micro samples of numerous heats of the alloy in annealed and heat treated conditions (from 1800-2300 F) conclusively proved that banded ferrite can cause cracking during upsetting. Small patches of ferrite as such are not harmful as long as there is no banding or chain-like continuity of the patches.*

*As can be seen in the photomicrograph above, banded ferrite becomes pronounced when the material is quenched from 2000 and 2100 F. Air quenching from 1900 F removes all evidence of banding, even from samples with excessive banding in the annealed state. These results were passed along to the material suppliers, and the banded ferrite was eliminated.*



# Nodular or Ductile Iron

by **John L. Everhart,** *Associate Editor, Materials & Methods*

*Nodular or ductile irons are a group of materials whose properties lie between those of gray irons and cast carbon steels. They can be cast at the same temperatures using the same procedures as are employed for gray iron castings. Their properties can be improved by heat treatment procedures used for the cast carbon steels. This manual discusses the mechanical and physical properties, heat treatment and applications of the commercial grades of nodular iron.*

**MATERIALS & METHODS MANUAL No. 120**

**This is another in a series of comprehensive articles on engineering materials. These special sections provide the reader with useful data on characteristics and uses of materials, parts and finishes.**

OCTOBER 1955

■ Possibly the most important advance in cast iron metallurgy during the past century is the development of a group of materials known variously as nodular iron, ductile iron, S. G. (spheroidal graphite) iron or spherulitic graphitic iron.

These new materials have the same basic compositions as common gray irons but differ from the latter in the shape of the graphite particles. In gray iron, the graphite occurs as flakes while in nodular or ductile iron, the structure has been described as nodular and as spheroidal. Regardless of the exact form, and there is still considerable disagreement on this point, the change in shape of the graphite particles has a great effect on the mechanical properties, and the new material is much more ductile than gray iron.

Spheroidal graphite iron is produced by inoculating the molten iron with magnesium, cerium, combinations of the two or various other compounds. The base composition is the same as that of gray iron and the inoculants serve only to cause the graphite to be rejected from the solidifying iron in a spheroidal rather than a flake form. Spheroidal graphite can be formed in any gray iron composition and has also been produced in austenitic and special alloy irons.

Nodular iron joins malleable iron in filling a need for a material whose properties lie between those of gray iron and steel; in many properties it resembles malleable iron. However, it has a major advantage in the fact that it is somewhat ductile as-cast and can be made quite ductile by a short-time anneal while malleable iron can be produced only by long-time annealing of white iron. Further, the section size of ductile iron castings is not limited while that of malleable iron castings is.

In some respects the nodular iron structure resembles steel. As a matter of fact, it is sometimes stated that the material is equivalent to a high silicon steel with the addition of graphite. Like steel, it can be heat treated to quite high strength levels. It has the advantage, however, that it can be cast at the same low temperatures and with the same procedures used for ordinary gray irons.

**ASTM TENSILE REQUIREMENTS**

| | Grade 80-60-03 | Grade 60-54-10 |
|---|---|---|
| Tensile strength, min, psi | 80,000 | 60,000 |
| Yield strength, min, psi | 60,000 | 45,000 |
| Elongation in 2 in., min, % | 3.0[a] | 10 |

[a] *Where strength is the major requirement, the elongation requirement may be waived by agreement.*

*It is intended that the properties given for Grade 60-45-10 be obtained by a graphitizing anneal although, if agreeable, castings are acceptable if the required properties are obtained without heat treatment.*

**STANDARD GRADES**

| Designation | Applicable Specification | Minimum Mechanical Properties | | |
|---|---|---|---|---|
| | | Ten Str, psi | Yld Str, psi | Elong, % in 2 in. |
| 60-45-10 | ASTM A339-51T<br>Mil-I-11466, class 5<br>AMS 5315[1]<br>Navy Spec. Mil-I-17166 (Ships)[2] | 60,000 | 45,000 | 10 |
| 80-60-03 | ASTM A339-51T<br>Mil-I-11466, class 4<br>AMS 5316 | 80,000 | 60,000 | 3 |
| 100-75-04 | Mil-I-11466, class 2 | 100,000 | 75,000 | 4 |
| 120-90-02 | Mil-I-11466, class 1 | 120,000 | 90,000 | 2 |

[1] *Requires 15% min elongation, unless taken directly from castings, 2.8% silicon max.*

[2] *Requires 40,000 psi min yield strength, 15% min elongation*

*Editor's Note: Specifications covering Grades 100-70-03 and 120-90-02 and a specification for use in the ASME code for pressure vessels at elevated temperatures are in preparation by the ASTM.*

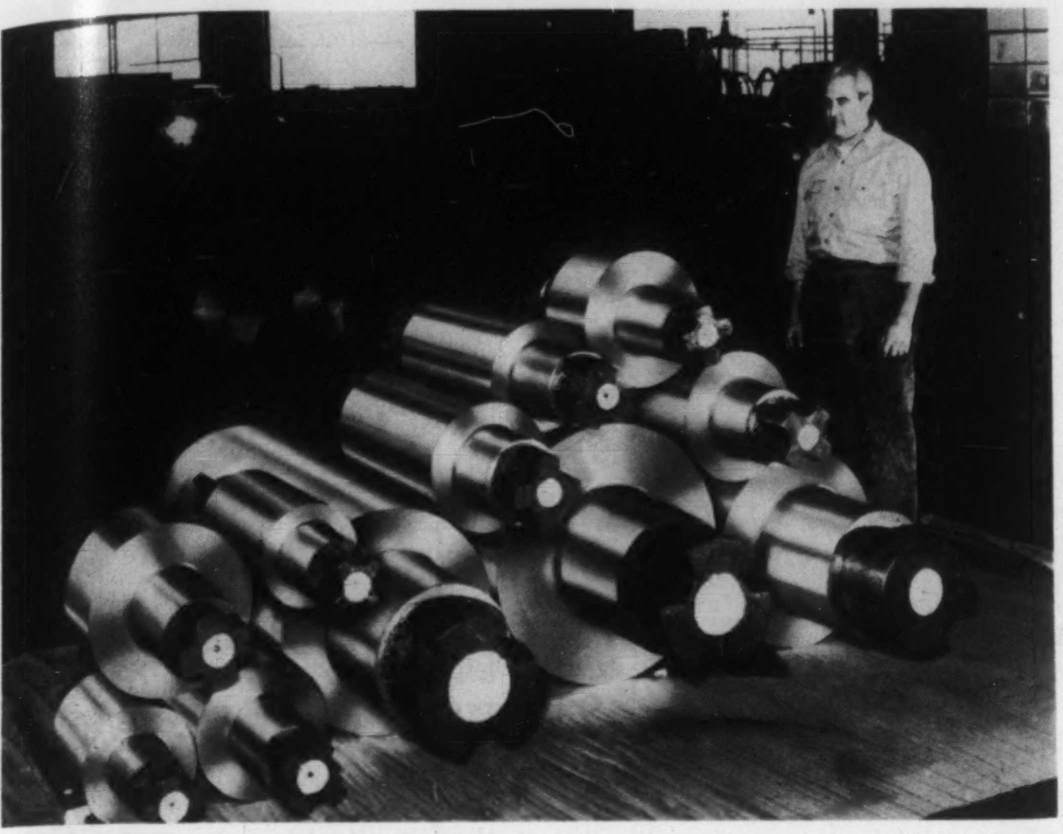
Announcement of the development of the new material was made about 7 years ago by two organizations, one of which called it *nodular iron*, the other, *ductile iron*. Considerable controversy over the proper name for the material exists today. One group calls it *nodular iron*, and this is the term used in the ASTM Designation; another calls it *ductile iron* while a third calls it *S.G.* (spheroidal graphite) iron. The latter term is becoming increasingly popular in Europe.

Regardless of the term used, certain grades have become established in commercial practice, and this manual discusses the properties and applications of these grades. No distinction is made among names, the terms, *nodular iron, ductile iron* and *S.G. iron* being used interchangeably.

## Standard grades

The ASTM defines nodular iron as "cast iron with the graphite substantially in spherical shape and substantially free of flake graphite". ASTM Designation A339 covers two grades, which are specified by their tensile properties (see table), and the designation includes the statement: "It is the intent of these specifications to subordinate chemical composition to physical properties; however, the quantities of any chemical elements in the iron may be specified by agreement between manufacturer and purchaser."

It has become the practice in classifying nodular or ductile irons to code them with a symbol which indicates their mechanical properties. Thus, the symbol 80-60-03 indicates an iron having the following minimum tensile properties: 80,000 psi tensile strength, 60,000 psi yield strength and 3% elongation. Although there are only two ASTM grades specified, there are four other grades which have received wide industrial acceptance, two of which are covered in government specifications. Applicable specifications are given in a table.



**Nodular iron rolls** *are replacing steel rolls in many mills for rolling skelp, plates, shapes, bars, rods, pipe and tubing.* *(Aetna Standard Engineering Co.)*

# Engineering Properties

### Castability

Discussion of the production of castings is outside the scope of this manual. However, a brief mention of nodular iron's casting properties will aid the engineer or designer in determining whether a particular design can be reproduced in this material.

Ductile iron resembles soft high-carbon gray iron in having a low melting point and good fluidity in the liquid state. With green sand molds and using normal foundry pouring temperatures, nodular iron will flow several inches in sections as small as 1/16 in. Thin sections have a tendency to chill. For average size castings, the gray iron shrink rule is applicable to ductile iron and, therefore, no special patterns are required. Castings of intricate shape can be produced readily by any of the procedures used for gray iron, such as green sand, shell molding, etc.

### Physical properties

The physical properties, melting point and so forth, of nodular irons are similar to those of gray irons of corresponding composition. Since these ductile irons compete with cast steels and malleable irons, comments on the relative properties of these two materials may be of interest.

In general, the density of 0.26 lb per cu in. holds for standard grades of nodular iron, gray iron and malleable iron. Corresponding values for cast carbon steels of structural grade are about 0.28 lb per cu in.

Like gray irons, the melting and freezing ranges of nodular irons depend to a great extent on the carbon equivalent of the iron, % carbon + 0.3% (silicon + phosphorus). Nodular irons generally freeze in the range 2050 to 2400 F. This is considerably lower than the freezing ranges of the cast carbon steels.

The electrical resistivity varies considerably, depending on the composition. Increase in silicon or carbon content raises the resistivity of the iron. For example, Type 60-45-10, containing 2.5% silicon, has a resistivity of 58 microhm-cm; with 3.0% silicon, the resistivity increases to 66 microhm-cm; and with 4% silicon, the value rises to 73 microhm-cm. The resistance of the austenitic grade is still higher, being about 102 microhm-cm. Resistivity of the standard grades of malleable iron is about 29 microhm-cm and of cast carbon steel, about 15 microhm-cm.

The room temperature thermal conductivity of nodular iron is roughly 25% lower than that of gray iron of similar composition. At higher temperatures, the conductivity curves converge. The conductivity is somewhat lower than that of the malleable irons and about 2/3 that of cast carbon steel.

The coefficient of thermal expansion of standard grades of nodular, gray and malleable irons is about $6.6 \times 10^{-6}$. The austenitic grade of nodular iron has a coefficient of $10.4 \times 10^{-6}$. Cast carbon steels average about $8.8 \times 10^{-6}$.

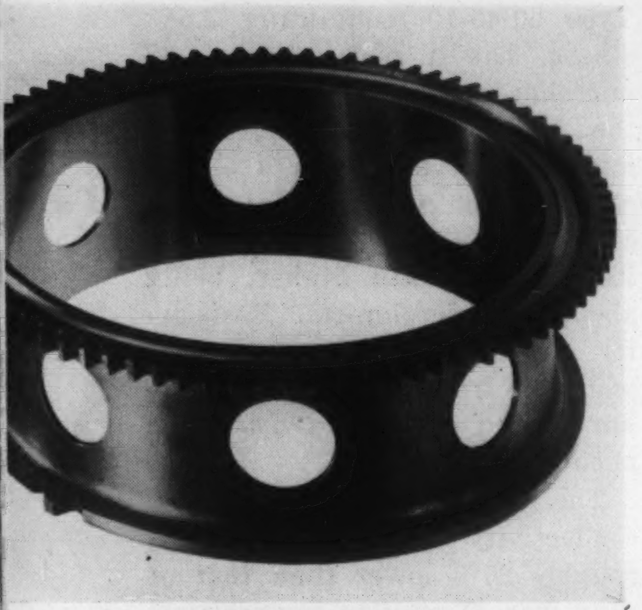
The modulus of elasticity of nodular iron varies with graphite content from 25,000,000 psi, to a minimum of about 22,000,000 psi. Gray iron has no true modulus of elasticity, but values of 16,000,000 to 20,000,000 psi are generally assigned to it. The modulus of standard grades of malleable iron is 25,000,000 psi while that of cast steel is about 29,000,000 psi.

Some of the physical properties of commercial grades of ductile iron are included in a table.

### Mechanical properties

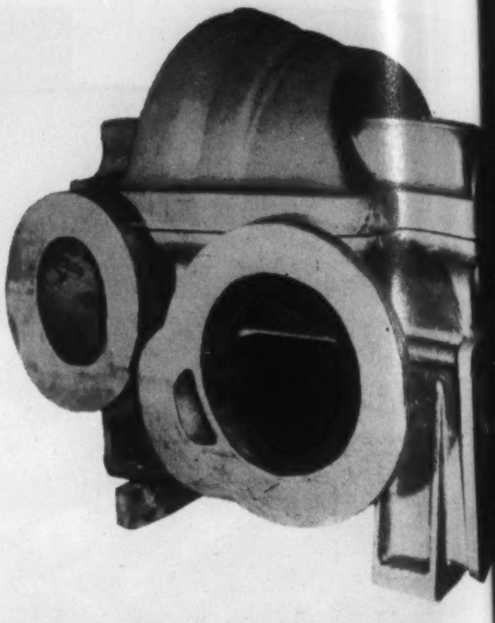
The mechanical properties of nodular irons depend on the structure which, in turn, is determined by the composition and heat treatment. The properties are also influenced to a minor degree by the size and distribution of the graphite particles.

Ferritic irons, defined as those containing a maximum of 10% pearlite, can be obtained in the as-cast condition with suitable compositions or by annealing pearlitic irons. Content of alloy-



**Control ring gear** *for an aircraft propeller cast from high strength ductile iron by the American Brake Shoe Co.*

**Valve housing** *for a high pressure hydraulic system.*
*(American Brake Shoe Co.)*



**Compressor housing** *for refrigeration service on a U. S. Navy vessel produced in ductile iron.*
*(Bethlehem Foundry & Machine Co.)*

ing elements, particularly silicon, determines the mechanical properties. Tensile strengths ranging from 80,000 to 90,000 psi, yield strengths of 40,000 to 70,000 psi and elongations of 12 to 25% are obtainable in these irons.

Pearlitic irons are obtained either as-cast or by normalizing. Properties can range from 80,000 to 130,000 psi tensile strength, 60,000 to 110,000 psi yield strength and 3 to 10% elongation.

Irons can also be produced in the quenched and tempered condition. Such irons generally have tensile strengths ranging from 100,000 to 160,000 psi, yield strengths of 80,000 to 130,000 psi and elongations of 2 to 10%.

The spheroidal graphite structure characteristic of nodular irons can also be produced in highly alloyed irons. These retain an austenitic structure to temperatures considerably below room temperature. Tensile strengths of about 60,000 psi, yield strengths of 30,000 to 40,000 psi and elongations of 10 to 40% can be obtained.

Excepting the austenitic grade, commercial nodular irons have as-cast structures which are predominantly pearlitic while ferritic structures are produced by heat treatment. As the structure changes from pearlitic to ferritic, strength drops and ductility increases. Properties of the commercial grades are given in a table.

In the absence of shrinkage, the material has only moderate section sensitivity both as-cast and after annealing. With increasing thickness, properties are lowered slightly. The ratio of yield to tensile strength decreases with section size from about 0.75, which applies to an iron in 2-in. sections having a silicon content of 2.5%, to as low as 0.64 for an iron in 6-in. sections containing 1% silicon.

There is a definite relationship between tensile strength, elongation and hardness in all types excepting the austenitic. The relationship of tensile strength to Brinell hardness for material as-cast or annealed is given as 420 to 1, and the ratio increases to 475 to 1 for normalized or quenched and tempered material. In properly made ductile iron, tensile strength and elongation can be found by making a hardness test. The relationship is shown in an accompanying graph.

### Ductility

Because nodular iron is a term used to describe a group of materials, it is necessary to define what is meant by ductility. Using elongation in the tensile test as a criterion, even as-cast nodular iron is greatly superior to gray iron. Annealed ferritic nodular irons are somewhat more ductile than malleable iron and comparable with cast low carbon steels. However, as-cast and heat treated nodular irons are not so ductile as cast carbon steels.

Explosion tests at the Naval Research Laboratory on castings free from notch defects show that fully ferritized nodular iron is capable of withstanding drastic deformation before fracture occurs. As in the case of steels, sharp notches are required to promote the initiation of brittle fractures at normal service temperatures under conditions which do not include plastic deformation.

### Impact strength

Phosphorus and silicon have a pronounced effect on the impact strength of ductile irons. For service under shock conditions, irons should be selected which have the lowest practical silicon and phosphorus content. An indication of the effect of these elements follows. The notched Charpy impact strength of ferritic irons of low silicon content is about 20 ft-lb at ambient temperatures. In a low phosphorus iron, if silicon content is above 3%, the value drops to 5 ft-lb or below and the material shows a brittle fracture. A similar effect results if phosphorus content is increased from 0.08 to 0.16% in an iron containing 2% silicon.

### TYPICAL PROPERTIES OF COMMERCIAL GRADES

| Designation | 80-60-03 | 60-45-10 | 100-75-04 | 120-90-02 | Austenitic | Heat Resistant |
|---|---|---|---|---|---|---|
| TYPICAL COMPOSITION, % | T.C. 3.3-3.8 | T.C. 3.4-4.0 | T.C. 3.4-3.8 | T.C. 3.4-3.8 | T.C. 3.0 | T.C. 2.8-3.8 |
| | Si 2.0-3.0 | Si 2.0-2.75 | Si 2.0-2.75 | Si 2.0-2.75 | Si 2.0-3.2 | Si 2.5-6.0 |
| | Mn 0.2-0.5 | Mn 0.2-0.6 | Mn 0.3-0.6 | Mn 0.3-0.6 | Mn 0.8-1.5 | Mn 0.2-0.6 |
| | P 0.06-0.08 | P 0.06-0.08 | P 0.08 max | P 0.08 max | P 0.2 max | P 0.08 max |
| | Ni 0-1.0 | Ni 0-1.0 | Ni 0-2.5 | Ni 0-2.5 | Ni 18-22 | Ni 0-1.5 |
| | — | — | Mo 0-1.0 | Mo 0-1.0 | Cr 0-2.5 | — |
| | Mg 0.02-0.07 | Mg 0.02-0.07 | Mg 0.02-0.07 | Mg 0.02-0.07 | — | Mg 0.02-0.07 |
| PHYSICAL PROPERTIES<br>Density, lb/cu in. | 0.257 | 0.257 | 0.257 | 0.257 | 0.268 | about 0.25 |
| Melting range, F | 2050-2150 | 2050-2150 | 2050-2150 | 2050-2150 | 2250 | 2050-2150 |
| Thermal cond, Btu/hr/sq ft/ft/ F | 18 | 20 | — | — | — | — |
| Coef of exp per F (70-400 F) | $6.6 \times 10^{-6}$ | $6.6 \times 10^{-6}$ | $6.6 \times 10^{-6}$ | $6.6 \times 10^{-6}$ | $10.4 \times 10^{-6}$ | — |
| Elect res microhm-cm at 75 F | 68[1] | 66[1] | — | — | 102 | — |
| Modulus of elasticity, psi | $22\text{-}25 \times 10^{6}$ | $22\text{-}25 \times 10^{6}$ | $22\text{-}25 \times 10^{6}$ | $22\text{-}25 \times 10^{6}$ | $18.5 \times 10^{6}$ | $22\text{-}25 \times 10^{6}$ |
| MECHANICAL PROPERTIES<br>Tensile strength, psi | 90,000-110,000 | 60,000-80,000 | 100,000-120,000 | 120,000-150,000 | 58,000-68,000 | 60,000-100,000 |
| Yield strength, psi | 60,000-75,000 | 45,000-60,000 | 75,000-90,000 | 90,000-125,000 | 32,000-38,000 | 45,000-75,000 |
| Elongation, % in 2 in. | 3-10 | 10-25 | 6-10 | 2-7 | 7-40[2] | 0-20 |
| Brinell hardness | 200-270 | 140-190 | 200-240 | 240-325 | 140-200 | 140-300 |
| Charpy impact str (unnotched) ft-lb | 15-65 | 60-115 | 35-50 | 25-40 | — | 5-115 |
| Charpy impact str (notched) ft-lb | 2-5 | 10-15 | — | — | 10-28[3] | — |

*[1] Iron containing 1% Si*
*[2] 25-40% with 0% Cr*
*[3] "V" notched*
*[4] Grades 100-75-04 and 120-90-02 are obtained by heat treatment involving normalizing or quenching and tempering*

Notched Charpy values range from 2 ft-lb for as-cast to about 15 to 20 ft-lb for annealed material in all commercial grades excepting the austenitic where the value reaches 28 to 30 ft-lb. In standard malleable irons, the notched impact value is about the same as in annealed ductile iron. Cast steel shows higher values. Unnotched Charpy values on nodular irons range from 15 to 115 ft-lb.

### Endurance properties

Endurance properties determined on ductile irons with different structures have indicated that the endurance ratio follows the pattern set with other ferrous materials. The stronger the material, the lower the ratio. For soft ferritic ductile irons, the unnotched endurance ratio runs from 50 to 55%. With the stronger irons, the ratio drops to 30 to 40% or even lower. These ratios are roughly comparable with those obtained on cast steels and malleable irons.

### Compressive strength

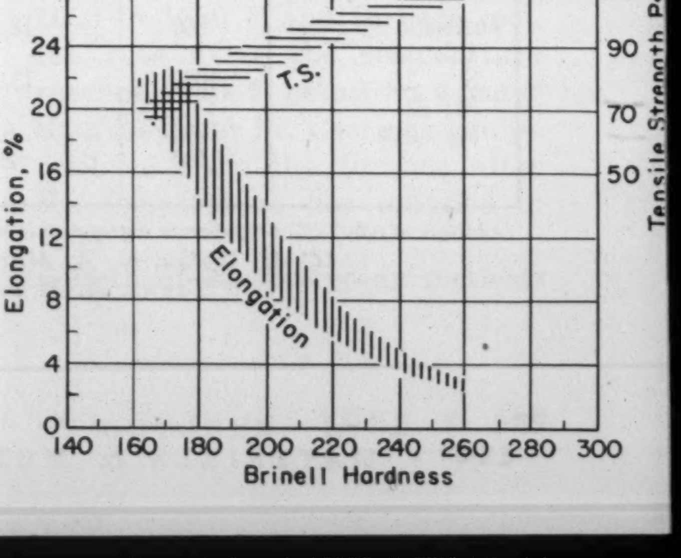
Gray iron has the unusually high ratio of 4 to 1 of compressive strength to tensile strength. Ductile iron does not have this characteristic but shows a ratio of perhaps 2 to 1 which is in the same range as that of malleable iron.

### Wear resistance

Because of the variety of factors contributing to wear of metals, there is no standard wear test procedure. Thus, it is possible to obtain widely varying results in attempts to compare metals on the basis of wear tests run under laboratory conditions.

Some authorities state that both laboratory and service tests indicate that ductile iron has good resistance to mechanical wear un-

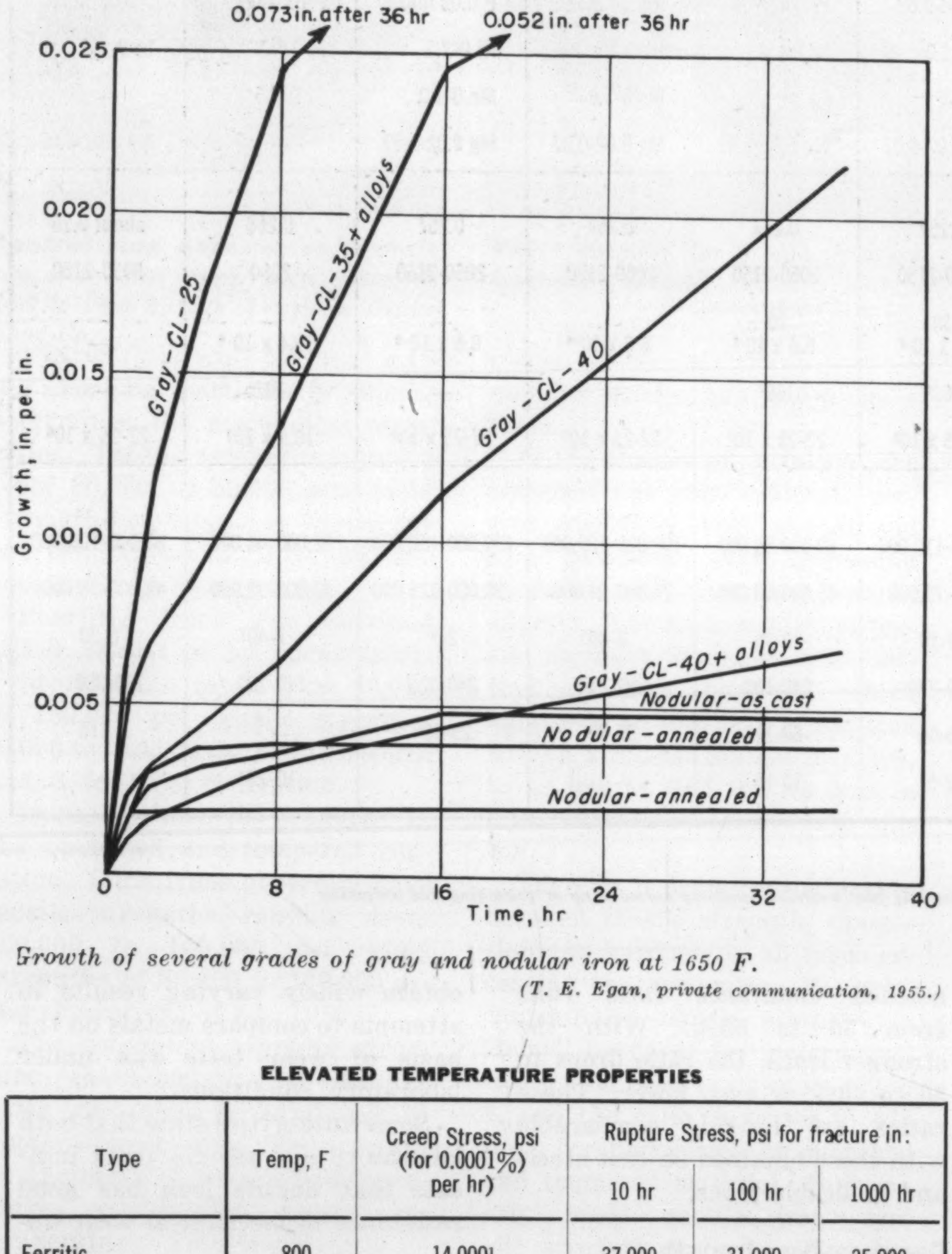
*Relationship between hardness, tensile strength and ductility of ductile iron in the as-cast condition.*
*(International Nickel Co.)*



der both lubricated and unlubricated conditions. Of course, conditions must be defined. Thus, ferritic ductile iron gears were equivalent in wear resistance to steel in one service test. In the case of a cylinder liner, ferritic ductile iron showed wear resistance equal to a pearlitic gray iron.

### Elevated temperature properties

Service at elevated temperatures generally involves not only a consideration of strength, but also, in the case of cast iron, the evaluation of growth and oxidation resistance. Nodular irons are far more resistant to growth and oxidation than gray irons at temperatures up to at least 1700 F, while both are superior in oxidation resistance to either cast or wrought low carbon steels. Increasing silicon content of cast iron improves its resistance to oxidation, and a ductile iron containing 6% silicon has excellent oxidation resistance up to 1800 F. However, this grade can be used only in applications where shock resistance is not a major requirement since it is far more brittle than the other grades at room temperature although ductility improves at high temperatures.



*Growth of several grades of gray and nodular iron at 1650 F.*

*(T. E. Egan, private communication, 1955.)*

**ELEVATED TEMPERATURE PROPERTIES**

| Type | Temp, F | Creep Stress, psi (for 0.0001%) per hr) | Rupture Stress, psi for fracture in: 10 hr | 100 hr | 1000 hr |
|---|---|---|---|---|---|
| Ferritic<br>(60-45-15) | 800 | 14,000[1] | 37,000 | 31,000 | 25,000 |
| | 1000 | 4000 | 13,000 | 10,000 | 7500 |
| | 1200 | 550 | 5000 | 3300 | 2200 |
| Pearlitic<br>(80-60-03) | 800 | 19,000 | 65,000 | 52,000 | 42,000 |
| | 1000 | 1750 | 26,000 | 17,000 | 9100 |
| | 1200 | 480 | 7100 | 4100 | 2400 |
| Austenitic<br>T.C. 3.0<br>Si 2.5<br>Ni 22<br>Mg 0.08 | 800 | 18,500 | 50,000 | 41,000 | 35,000 |
| | 1000 | 13,000 | 33,000 | 26,000 | 21,000 |
| | 1200 | 5700 | 15,500 | 12,000 | 9000 |
| | 1400 | 2000 | 7800 | 5700 | 3300 |

[1] *Addition of 0.5-0.8% molybdenum increases this value to about 27,000 psi*

*(C. R. Wilks, N. A. Matthews and R. W. Kraft, Jr., Trans. ASM vol 47, p 611, 1955.)*

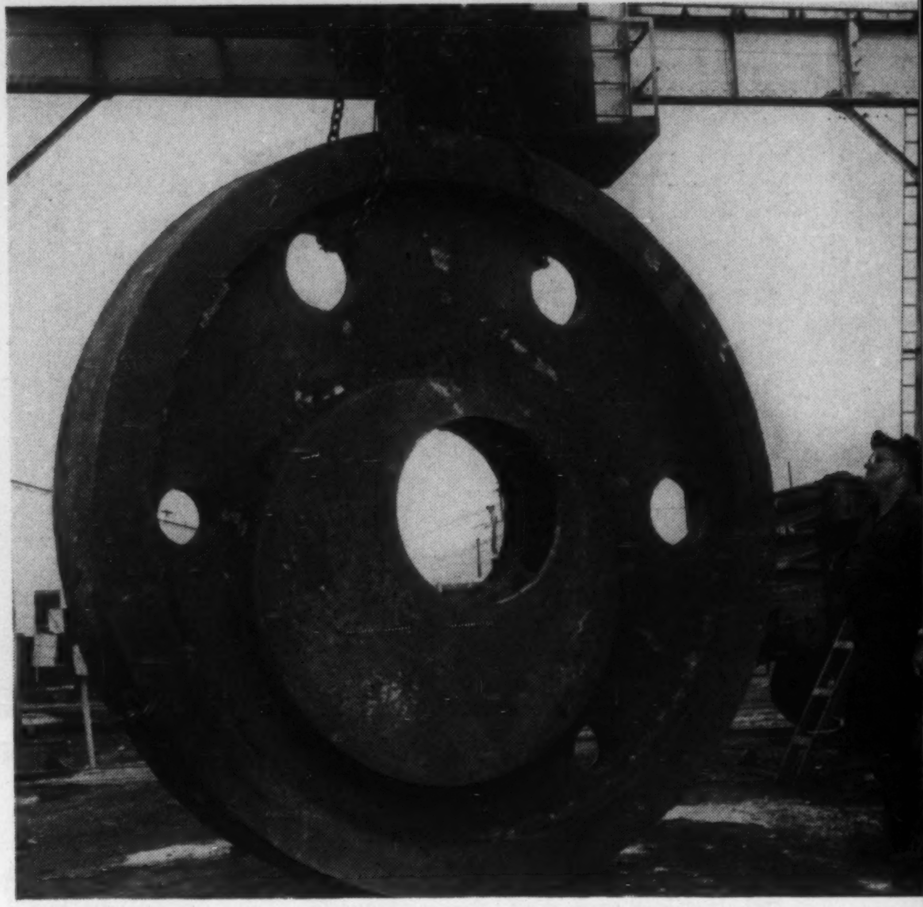
Strengths of various grades of ductile iron have been determined at several elevated temperatures and are given in a table. In short time properties, nodular irons compare roughly with cast steels up to 800 F. In the standard grades, pearlitic irons appear to be superior to ferritic grades in short time and rupture strengths. However, this superiority persists in long time service only up to temperatures of about 800 F. At higher temperatures, pearlitic iron, which is unstable structurally, gradually changes to a ferritic material which apparently has lower creep strength than the standard ferritic grade. The creep strength of the stable ferritic grade from 800 to 1200 F appears to be somewhat lower than that of cast low carbon steel.

Austenitic grades of ductile iron are considerably stronger above 1000 F than either ferritic or pearlitic grades. They can be used up to temperatures of 1300 to 1400 F. Addition of chromium to the austenitic grade in amounts up to 2.5% increases load carrying ability, and this modified material is said to have elevated temperature strengths comparable with 18:8 stainless steel.

### Low temperature properties

Possibly the best comment on the low temperature properties of ductile iron is the fact that the Navy has issued a specification for ductile iron for use on ships

**Tension reel casting** *for a continuous galvanizing line is annealed in a car-type furnace.*
*(Aetna Standard Engineering Co.)*



**Gear blank** *weighing 22,500 lb being readied for shipment.*
*(Aetna Standard Engineering Co.)*

in all climates. Gray iron has been banned from such service for many years. Impact resistance is the major criterion for approval, and ductile iron castings have passed the temperature-impact tests.

Investigations carried on at the Naval Research Laboratory have shown that fully ferritized material is required for optimum notch toughness and that silicon and phosphorus should be held to the lowest possible limits. The Charpy v-notch transition ranges of low silicon and phosphorus (lower than normal commercial practice) ferritized nodular irons are equivalent to those of average quality cast and rolled mild steels while irons of commercial composition are somewhat less resistant to brittle fracture.

### Corrosion resistance

Limited tests on ductile irons of various standard grades show that they have approximately the same resistance to corrosion as gray irons of similar composition. Comparison tests in the atmosphere, aerated tap water, dynamic tests in sea water and tests in various salt solutions confirm this contention. The standard grades of nodular iron, however, appear to be superior to cast low carbon steels.

Austenitic grades of ductile iron are greatly superior to the pearlitic or ferritic grades in resistance to acids, alkalis and salts.

## Processing and Fabricating

### Heat treatment

By suitable control of composition, particularly silicon content, nodular irons can be produced which have structures ranging from practically 100% pearlite to 100% ferrite. However, in normal commercial practice, the as-cast structure generally consists of both pearlite and ferrite in proportions which are largely determined by section size. Unless considerable care is taken, very thin sections can contain primary carbide. Many heat treatments employed on nodular irons are similar to those used on steels. As a matter of fact, it has been suggested that treatments suitable for a high carbon, silicon steel can be employed for ductile iron.

The principal heat treatment used in the production of nodular iron is a ferritizing anneal. The softest and most ductile iron is obtained by heating in the range 1600 to 1650 F, cooling to 1275 or 1300 F and holding for periods of 1 to 3 hr, furnace cooling to 1100 F and air cooling.

An alternate procedure, which is simpler to apply, particularly in the handling of large batches of castings, is to heat in the range 1600 to 1650 F and furnace cool, the rate after the temperature reaches 1450 F being no greater than 35 F per hr. Castings can be removed from the furnace after the temperature has dropped to 1200 F.

Both of the preceding methods

**Hydraulic pressure cylinders** *are produced from nodular iron because close grained structures are obtainable.*
*(Aetna Standard Engineering Co.)*

apply when primary carbides are present in the as-cast structure. If carbides are not present, the iron can be annealed by heating to 1300 F for periods ranging from 1 to 5 hr, furnace cooling to 1100 F, and either furnace cooling or air cooling to ambient temperature. The time required for an individual casting depends on such factors as section size and composition.

Nodular irons can be heat treated to obtain other structures also, e.g., pearlitic-ferritic, pearlitic or tempered martensitic.

For pearlitic-ferritic structures, the material can be heated to 1600 or 1650 F, cooled rapidly and reheated at 1100 to 1300 F. An alternate procedure is to heat to 1600 or 1650 F, cool to the range 1100 to 1300 F and hold in that temperature range to produce an isothermal transformation of the material. Improvement in ductility with increased time of isothermal transformation or tempering is related to the increase in the ratio of ferrite to pearlite in the structure.

To develop pearlitic structures, the iron can be normalized by air-cooling from temperatures of 1600 to 1650 F.

To develop tempered structures, best results are obtained by quenching from just above the upper critical temperature. Depending on composition, suitable temperatures range from 1400 to 1650 F. Temperatures should not exceed 1650 F for the austenitizing treatment, or excess carbon is dissolved. Time of heating depends on the prior structure of the iron. Castings having a Brinell hardness below 220 are essentially ferritic in structure and, thus, have little carbon in solution. Such castings require soaking at temperature for about 1 hr. Castings having hardness values above 220 Brinell can be soaked for shorter periods.

Quenching from the range 1400 to 1650 F into oil or water pro-

**Hydromatic actuating cam** *for use on armored vehicles produced from nodular iron by Vulcan Foundry Co.* *(Meehanite Metal Corp.)*

**EFFECT OF HEAT TREATMENT**

| Condition | Ten Str, psi | Yd Str, psi | Elong, % | Brinell Hardness |
|---|---|---|---|---|
| As cast | 105,000 | 70,000 | 6 | 240 |
| 3 hr at 1650 F, furnace cooled to 1275 F, held 5 hr, furnace cooled to 1100 F, air cooled | 66,000 | 51,000 | 20 | 155 |
| 2 hr at 1600 F, air cooled, tempered 1 hr at 1200 F | 134,000 | 92,000 | 8 | 275 |
| 2 hr at 1600 F, oil quenched, tempered 1 hr at 900 F | 152,000 | 136,000 | 4 | 315 |

*Composition: T.C. 3.50, Si 2.75, Mn 0.35, P 0.04, Ni 1.00*
*Properties determined on ½ in "Y" bars*

*(International Nickel Co.)*

**Pump casing** *(right), 6340 lb, and* **cover,** *1974 lb, cast from S. G. iron by Farrel-Birmingham Co., Inc.*

duces a martensitic structure which can be tempered by heating in the range 800 to 1300 F. Highest strength and lowest ductility result from tempering at 800 to 900 F. Strengths of 160,000 psi and elongations of 2.5% are obtainable by this treatment. Reduced strength with increased ductility can be obtained by tempering at the upper end of the range. Response to tempering depends on the hardenability and section size as it does in steel.

### Surface hardening

Nodular irons can be surface hardened by conventional induction or flame hardening methods. Prior structure and composition influence the operation, but satisfactory results can be obtained in the commercial grades on all structures which have not been annealed to the fully ferritic condition. To obtain minimum case depths, structures consisting of the maximum quantity of uniformly distributed combined carbon are necessary. Deeper cases result if considerable quantities of free ferrite are present. Maximum surface hardness values of Rockwell C58 are obtainable. The matrix has a hardness of about C65 but over-all hardness is reduced by the presence of graphite.

Fully annealed ferritic irons cannot be hardened satisfactorily by these methods although some improvement is possible. The maximum hardness obtainable is about Rockwell C44 to C46. The austenitic grades cannot be hardened by induction or flame hardening methods.

The Japanese report that S.G. iron can be chromized successfully by the chromium chloride process. A chromized layer, 0.014 mm thick, is produced by passing the chloride over the surface of the iron for 5 hr at a temperature of 1800 F. Wear tests on the chromized surface showed a weight loss ½ that obtained with untreated ductile iron.

### Joining

Ductile iron can be welded by most fusion welding processes providing certain precautions are taken. For maximum ductility, welding should be done on fully annealed material. The composition of the material will also influence weld quality. Best results are obtained when the content of elements, such as nickel and manganese which increase hardenability, is restricted. When welding with nickel-iron rods, phosphorus content should be held to a maximum of 0.10%; with mild steel rods, phosphorus must be held to 0.05%. Most consistent welds have been produced with

**SURFACE HARDENING OF DUCTILE IRON**

| Structure | Flame Hardening with progressive quenching | | Flame Hardening with instantaneous general quenching[2] | |
|---|---|---|---|---|
| | Rockwell Hardness at Surface | Depth of Hardening,[1] in. | Rockwell Hardness at Surface | Depth of Hardening, in. |
| Ferrite/Pearlite (30% Ferrite) | C58-59.5 | 0.125-0.145 | C60 | 0.27 |
| Ferrite[3] | C33 | 0.02 | C48 | 0.19 |

[1] *Depth at which Vickers hardness drops below 500*

[2] *Heating time 41 sec, quench into water*

[3] *Same iron annealed*

*(Balley, Chory and Grilliat, Foundry Trade Journal, Feb. 4, 1954.)*

the 60 nickel-40 iron rods.

Mechanical properties of the joints are somewhat inferior to the properties of the castings. Joints in the pearlitic irons are lower in strength while those in ferritic irons lose some ductility. The ductility can be restored by heat treatment. Another result of welding is the formation of a hard zone which is difficult to machine in the iron adjacent to the weld. Heat treatment after welding produces a joint as machinable as the base material.

Ductile irons can be brazed also by conventional processes if certain precautions are taken.

*Metal-arc welding*—Best results in metal-arc welding are obtained using coated 60-40 nickel-iron electrodes of the smallest gage possible, welding continuously rather than intermittently and employing the lowest possible welding current. It is generally agreed that preheating to 600 F is beneficial since it permits welding with currents of 100 amp or even 75 amp and, thus, mimimizes the amount of parent metal melted during the operation.

For optimum machinability, are welded joints should be fully annealed after welding by procedures mentioned in the section on heat treatment. In the as-welded condition, joints made on annealed nodular iron are easier to machine than those made on the as-cast material.

Nodular iron can be joined to other materials also using the nickel-iron rod. Successful joints to mild steel, stainless steel, Inconel, nickel and Monel have been reported.

High strength fillet welds have been obtained in joining austenitic ductile iron to 18:8 sheet by using a coated rod corresponding to AISI 431 (made by coating AISI 430 with 2% nickel) and manual arc welding with reversed polarity current.

*Inert-gas-metal arc welding* can be employed successfully with a coated 60-40 nickel-iron filler wire, shielding with argon and employing reversed polarity current. Backing can be carbon or copper.

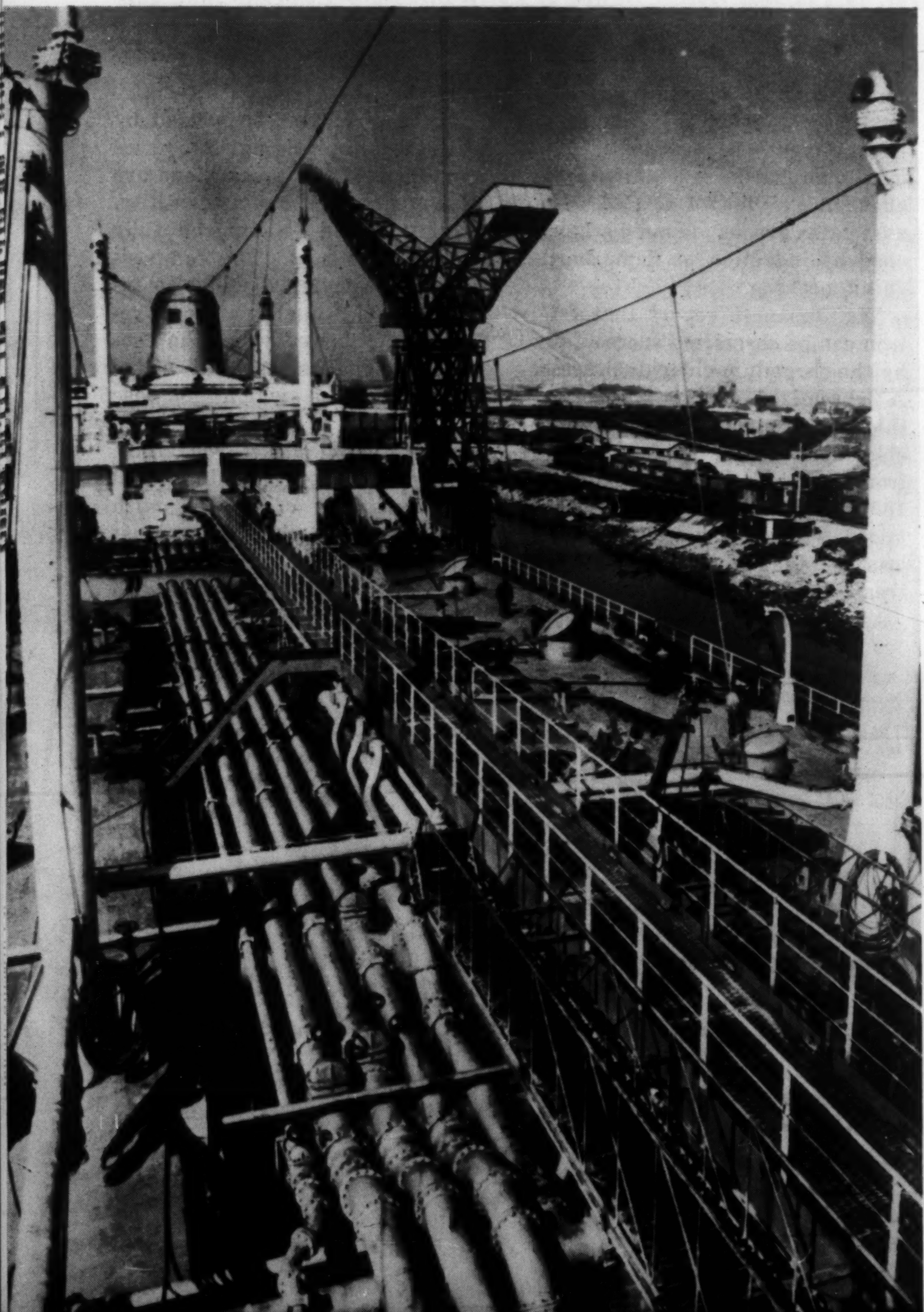
*Inert-gas-tungsten arc welding* has been investigated to some extent, but additional work is required to determine whether it can be applied generally.

*Submerged arc welding*—This method has been used to join ductile iron to mild steel, but only limited experience has been reported in the use of this procedure.

*Oxy-acetylene gas welding*—Nodular iron can be welded with the oxy-acetylene flame if a suitable filler rod is employed. Successful results are obtained in the field by skilled welders if a cast iron rod containing 0.2% cerium is used. Welding should begin with a shallow root weld and should then be followed immediately with the main deposit to build the full thickness in one pass. A high ratio of heat input is required and a large pool of molten metal must be maintained.

*Brazing*—Nodular irons can be brazed by conventional processes, but certain precautions are necessary. Since the structure can be

**Ductile iron piping** *installed on deck of a French tanker. This material is used widely in France for piping; it is sufficiently ductile to be fitted by bending and has corrosion resistance against most environments similar to gray iron.* *(Pont-a-Mousson, France.)*

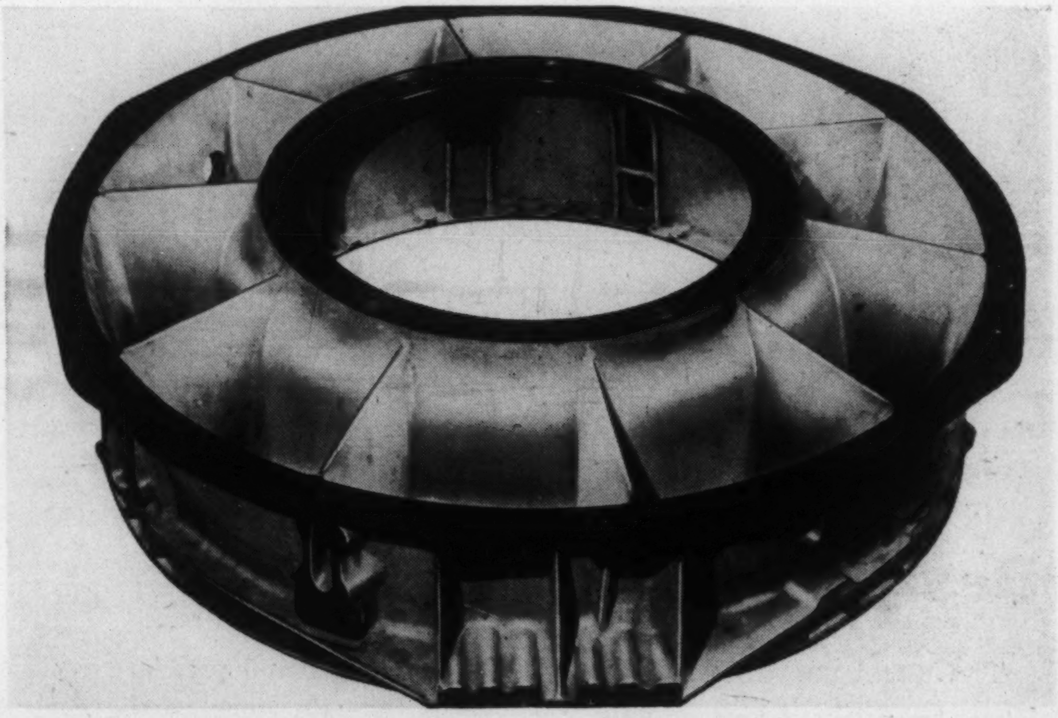


**RELATIVE MACHINABILITY OF GRAY IRON AND NODULAR IRON**

| Structure | Brinell Hardness | Ten Str, psi | Elong, % 2 in. | Cutting Speed, fpm for 200 cu in. tool life |
|---|---|---|---|---|
| FLAKE-GRAPHITE IRONS | | | | |
| Acicular | 263 | 59,000 | | 150 |
| Fine Pearlite | 225 | 45,000 | | 310 |
| Coarse Pearlite | 195 | 35,000 | | 325 |
| Ferrite (annealed) | 100 | 16,000 | | 960 |
| NODULAR GRAPHITE IRONS | | | | |
| 80% Fine Pearlite—20% Free Ferrite | 265 | 97,000 | 2 | 200 |
| 40% Fine Pearlite—60% Ferrite | 215 | 93,000 | 4 | 310 |
| 40% Fine Pearlite—60% Ferrite | 207 | 88,000 | 17 | 420 |
| Ferrite (annealed) | 183 | 77,000 | 20 | 600 |
| Ferrite (annealed) | 170 | 70,000 | 22 | 970 |

(*U. S. Air Force Machinability Report, 1950.*)

**Horizontal engine bearing back** *made from S.G. Iron. The part was originally made of cast steel, grade 65-30.* *(Cooper-Bessemer Corp.)*



**Center bearing support** *for Sapphire engines with 18:8 struts welded to the ductile iron inner and outer rings.* *(American Brake Shoe Co.)*

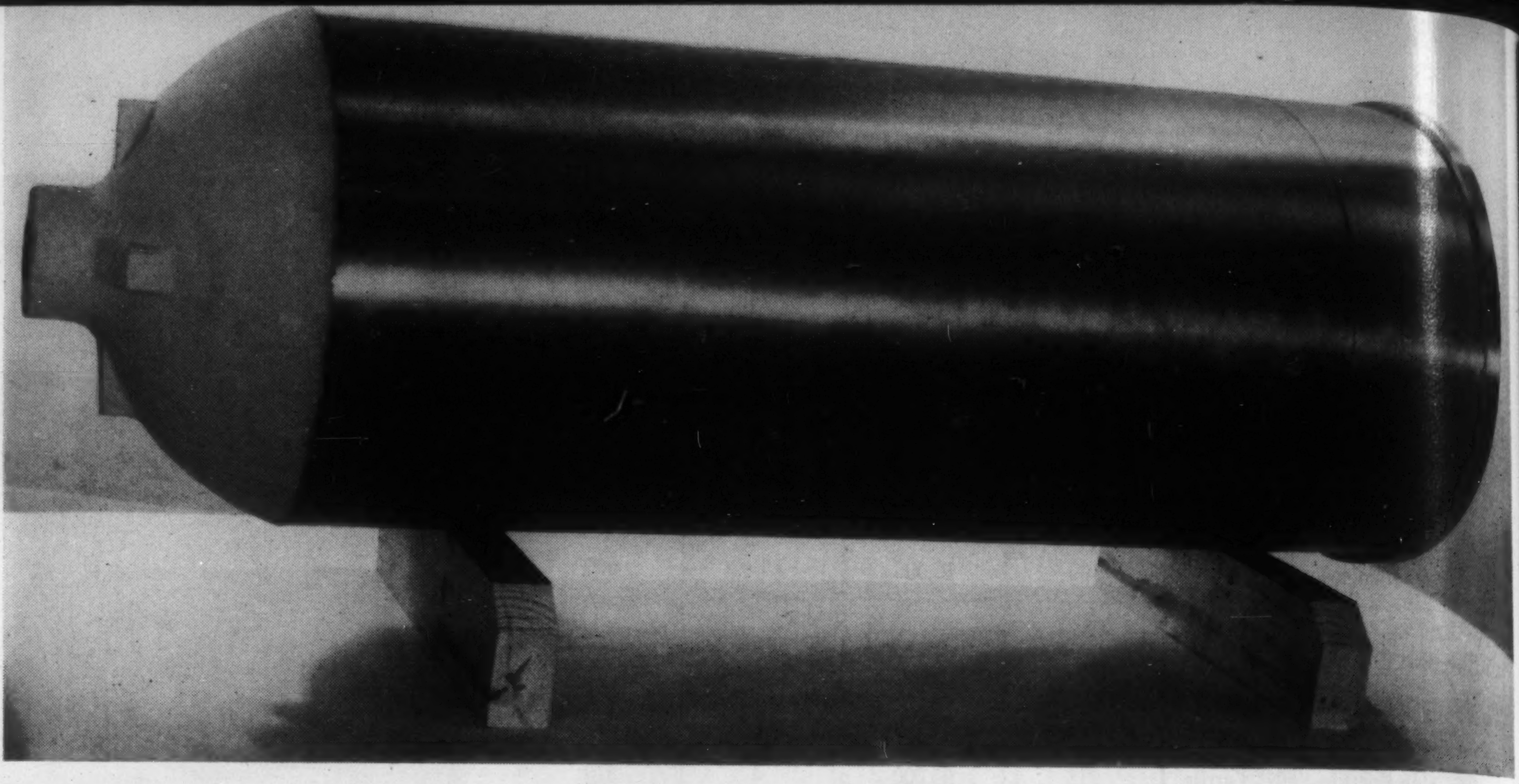
altered by heating above 1400 F, the lower melting BAg filler metals should be used. Those containing nickel, such BAg-3 and BAg-4, produce higher strength joints than the nickel-free grades. AWS Brazing Flux type 3, containing a combination of boric acid, borates and fluorides or fluoborates, is suitable.

### Machinability

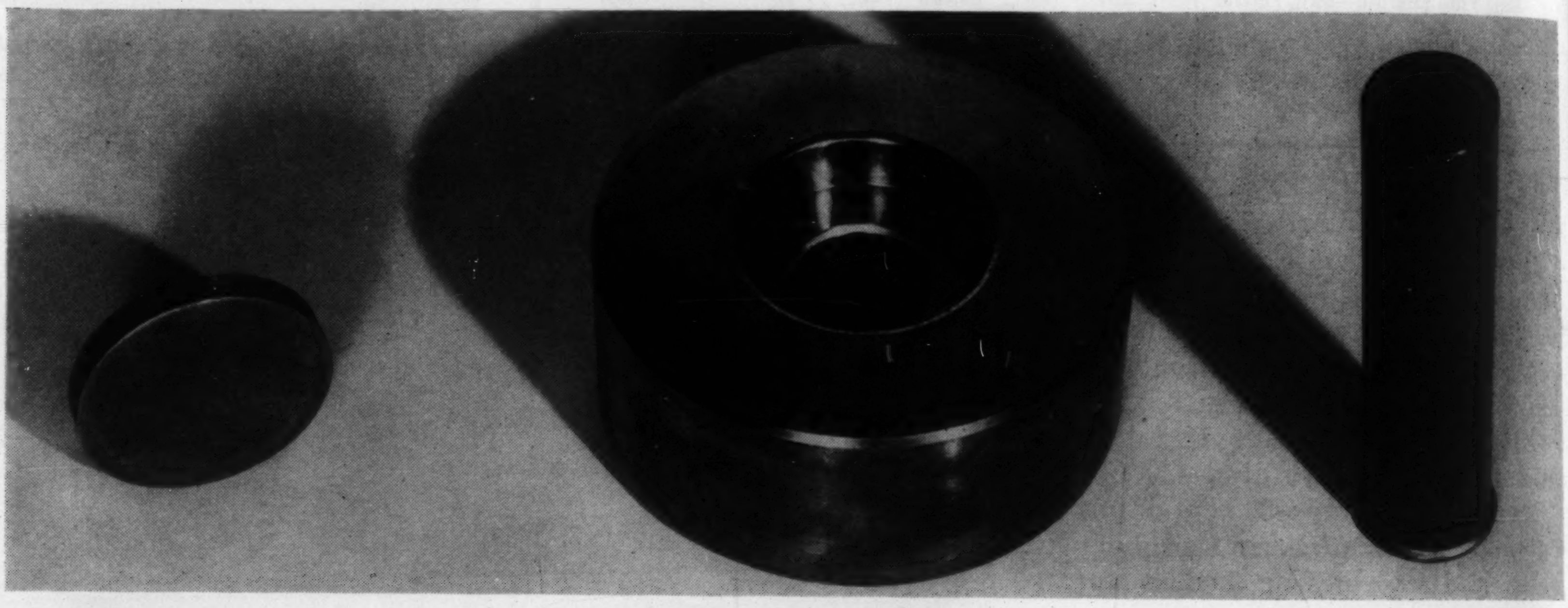
Relative machinability of ordinary gray irons (containing flake graphite) and nodular irons is compared in an accompanying table. The comparison is made on the basis of the cutting speed which can be used to obtain a tool life of 200-cu in. metal removal. In flake-graphite irons, the least machinable iron is that having an acicular structure, while the most machinable is a ferritic iron produced by annealing. There is a marked improvement in tool life when the iron is annealed to produce a fully ferritic structure.

Tool life of nodular graphite irons improves with increase in ductility and transformation to a fully ferritic structure by annealing. The softest nodular iron, while considerably stronger than any of the gray irons, can be machined at rates of 970 ft per min, a speed which can be equaled only when cutting a fully annealed flake-graphite iron with one-quarter the strength. The strongest nodular iron, although 50% stronger than acicular flake-graphite iron, can be machined at a cutting speed ⅓ higher for the same tool life. These results indicate that the nodular irons have excellent machinability in both as-cast and annealed conditions.

The mechanical properties of nodular irons approach those of cast steels, and the irons may be expected to compete with cast steels in some applications. Relative machinability of nodular irons and cast steels indicates that the two materials have about the same tool life if proper combinations of feed, speed and tool materials are employed. However, annealed nodular irons can be machined at considerably higher speeds than cast steels for a given tool life.



**Clamp cylinder** *for plastics molding machine cast from grade 80-60-03 by Lufkin Foundry & Machine Co.*



**Heading die** *made of ductile cast iron produced 875,000 brass cartridge cases compared with an average of 50,000 units for the tool steel die used previously.*

*(State Foundry & Machine Co.)*

# Design Considerations

The usual practices followed in good casting design should be followed in designing for nodular iron applications. Dimensional tolerances are about the same as those employed for gray iron excepting on the cope surface which is often padded slightly to assure removal of surface defects on machining.

Most consistent uniformity of properties is obtained in heat treated castings, particularly if the design is such that it combines light and heavy sections of widely different thicknesses.

The following brief comparison of nodular iron with gray iron and steel, as applied specifically to crankshafts and pressure vessels, will indicate some further points which the engineer should consider in designing with nodular iron.

### Crankshafts

Large crankshafts for reciprocating internal combustion engines are usually made of forged steel although cast steel or gray iron are employed for some types. A comparison of the properties of crankshafts made from steel, gray iron and S.G. iron is given in a table. The strength of the S.G. iron is equivalent to that of the carbon steel and much higher than the gray irons. The elongation is much lower than that of the steels, and this indication of lower ductility is confirmed by the impact test results, but at least one authority believes that high ductility is not a requirement of crankshafts. In his opinion, a crankshaft cannot continue to function satisfactorily if it is overloaded to such an extent that plastic yielding occurs; it might just as well be broken.

One of the most important properties of a crankshaft material is notched fatigue strength. Although nodular iron is more sensitive to notches than gray iron, the sensitivity is no greater than the steels, and additional

**PROPERTIES OF PRESSURE VESSELS**

| | Class 40 Gray Iron | Class 60 Gray Iron | Cast Steel | Nodular Iron |
|---|---|---|---|---|
| Tensile Strength, psi | 44,700 | 71,900 | 72,200 | 67,400 |
| Yield Strength (0.2% offset), psi | (a) | (a) | 45,600 | 52,500 |
| Elongation, % | (b) | (b) | 20.5 | 6.0 |
| Reduction of Area, % | (b) | (b) | 25.1 | 4.7 |
| Brinell Hardness | 180 | 254 | 141 | 180 |
| Endurance Limit, psi | 16,000 | 24,500 | 26,000 | 21,500 |
| Bursting Pressure, psi | 7200 | 8250 | 16,200(c) | 14,750 |

*Note: Properties determined on samples taken from the vessels*
(a) *Do not show yield strengths.*
(b) *No appreciable elongation or reduction of area in gray iron.*
(c) *Steel vessel did not burst but distorted beyond ability to seal the pressure.*

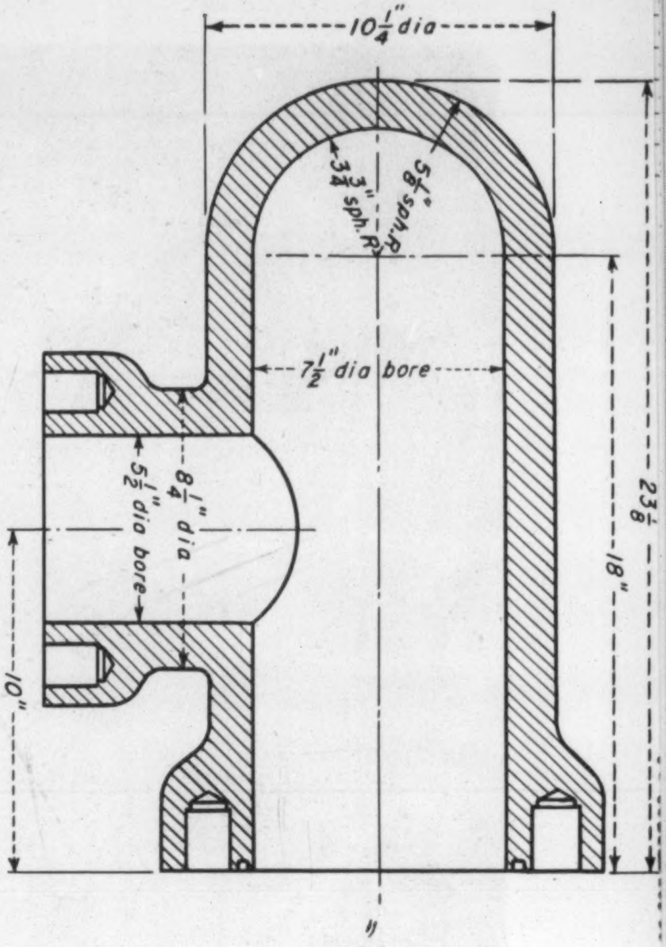
(*T. E. Eagan, Steel, Dec. 6, 1954.*)

**PROPERTIES OF SOME BRITISH CRANKSHAFT MATERIALS**

| | Forged Carbon Steel, quench. and temp. | Forged Ni-Cr-Mo Steel, heat treat. | Cast Iron, 20 ton/sq in.[c] min ten str | Alloy Cast Iron, 3.5 Ni-1 Mo acicular | S.G. Cast Iron Pearlitic |
|---|---|---|---|---|---|
| Tensile strength, psi | 81,000 | 130,000 | 49,000 | 58,000 | 90,000 |
| Yield strength, psi | 45,000 | 112,000 | | | 67,000 |
| Elongation, % | 25 | 23 | <1 | <1 | 2 |
| Brinell hardness | 260 | 269 | 220 | 280 | 260 |
| Modulus of elasticity, psi | 29 x 10⁶ | 29.5 x 10⁶ | 18-20 x 10⁶ | 22 x 10⁶ | 25 x 10⁶ |
| Modulus of rigidity, psi | 11 x 10⁶ | 11 x 10⁶ | 8.6 x 10⁶ | 8.6 x 10⁶ | |
| Izod impact strength (notched), ft-lb | 30 | 60 | <1 | 6.5 | 3.5 |
| Endurance limit (unnotched), psi | 35,000 | 65,000 | 16,000 | 27,000 | [b] |
| Endurance limit (notched 0.05 in. radius), psi | 18,000 | 39,000[a] | 13,000 | 20,000 | [b] |
| Reduction due to notch, % | 49 | 40[a] | 18 | 26 | [b] |
| Vibration damping capacity | Low | Low | High | High | Medium |

[a] *60 deg sharp notch*
[b] *On ferritic S.G. iron, the author reports: endurance limit unnotched, 24,000 psi, notched, 19,000 psi, reduction due to notch, 24%. (Editor's note: On a pearlitic S.G. iron of similar strength, others report, endurance limit unnotched, 40,000 psi, notched (45 deg "V"), 26,000 psi, reduction due to notch, 35%.)*
[c] *Tensile strength about midway between Classes 40 and 50, gray iron*

(*R. N. Riley, Foundry Trade Journal, May 15, 1952.*)



*Sketch of small pressure vessel designed for comparison of properties of cast steel, gray iron, nodular iron and malleable iron.*
(*T. E. Egan,* Steel, *Dec. 6, 1954.*)

work may show that the notch-fatigue ratio is closer to that of malleable iron than to the steels.

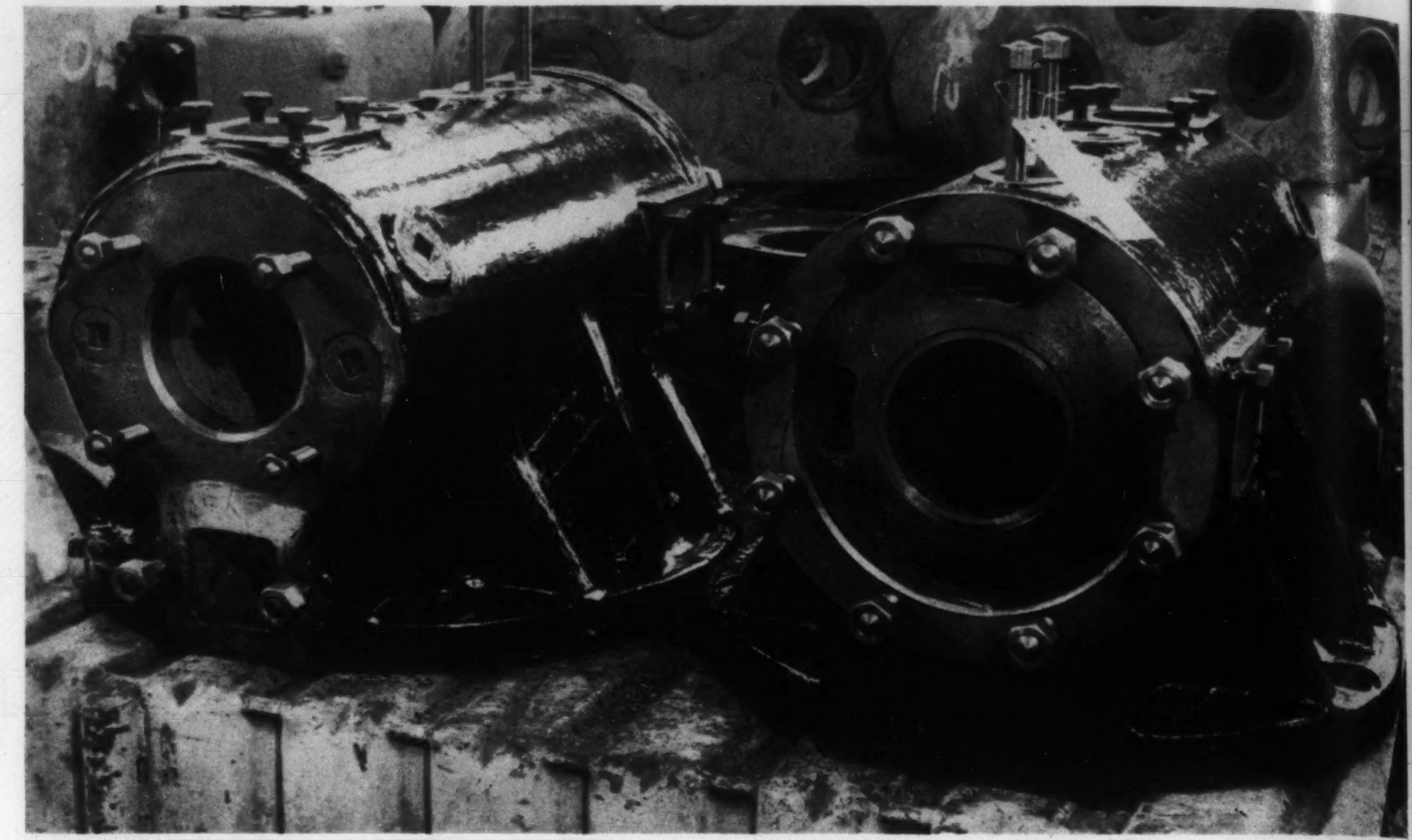
The elastic and rigidity moduli determine the shaft deflection which will occur. Under a given load, a pearlitic nodular iron will deflect 20% more than a steel shaft of similar proportions, but an acicular flake-graphite iron would deflect 50% more than the steel. Conversely, for a given bearing misalignment, the resulting bearing loads will be 33% less for the acicular iron and 17% less for the nodular iron than for the steel.

Considerations such as these are leading to the employment of nodular irons in crankshafts for various sizes of diesel engines particularly.

### Pressure vessels

A small pressure vessel, designed to compare the properties of gray iron, cast steel and nodular iron, is shown in an accompanying sketch. Results of the tests are given in a table. Tensile strengths of cast steel, nodular iron and class 60 gray iron were practically the same, while class 40 gray iron had much lower strength. Endurance limits were in the same relationship. Bursting pressures required for the ductile materials were almost twice those for the non-ductile types. In a hydraulic pulsating fatigue test, gray iron class 40 had a fatigue limit of 1450 psi; gray iron class 60, 2350 psi; nodular iron class 64-45-10, 3100 psi; and cast steel A27 65-30, 3350 psi.

These materials were rated for pressure vessel service as cast steel, 100%; nodular iron, 93%; class 60 gray iron, 70%; and class 40 gray iron, 43%.



**Horizontal gas engine head.** *This part was formerly made of cast steel grade 65-30 (ASTM specification A27). The part is now produced from 60-45-10 S.G. iron.* *(Cooper-Bessemer Corp.)*

# Applications

Ductile iron castings are made in sizes ranging from a few ounces to 20 tons generally, while the largest produced so far weighed about 50 tons. Some typical applications of the various grades are given in a table and discussed briefly below.

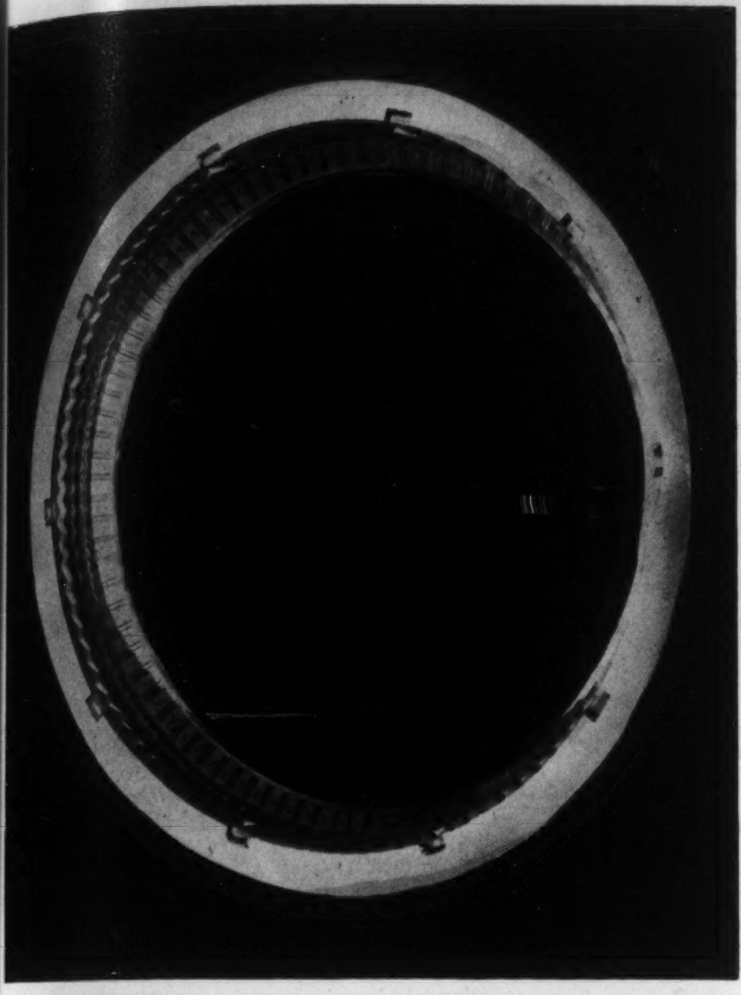
*Type 80-60-03* has maximum strength in the as-cast condition, responds readily to flame or induction hardening and can be cast against a chill to produce an abrasion resistant surface containing free-carbides. It is used in applications requiring resistance to wear and good strength in automotive, diesel, agricultural, heavy machinery, mining and related industries.

This grade has been used to replace cast aluminum pistons in railroad diesel engines, the advantage being increased heat and wear resistance. Another application where heat resistance is advantageous is in a cement kiln. Here this grade of ductile iron replaced stainless steel as a throat liner operating at 1250 to 1650 F. Among other parts produced from 80-60-03 are lathe face plates, v-belt pulleys, extension shafts, thrust bearings, drop hammer dies and plow shares.

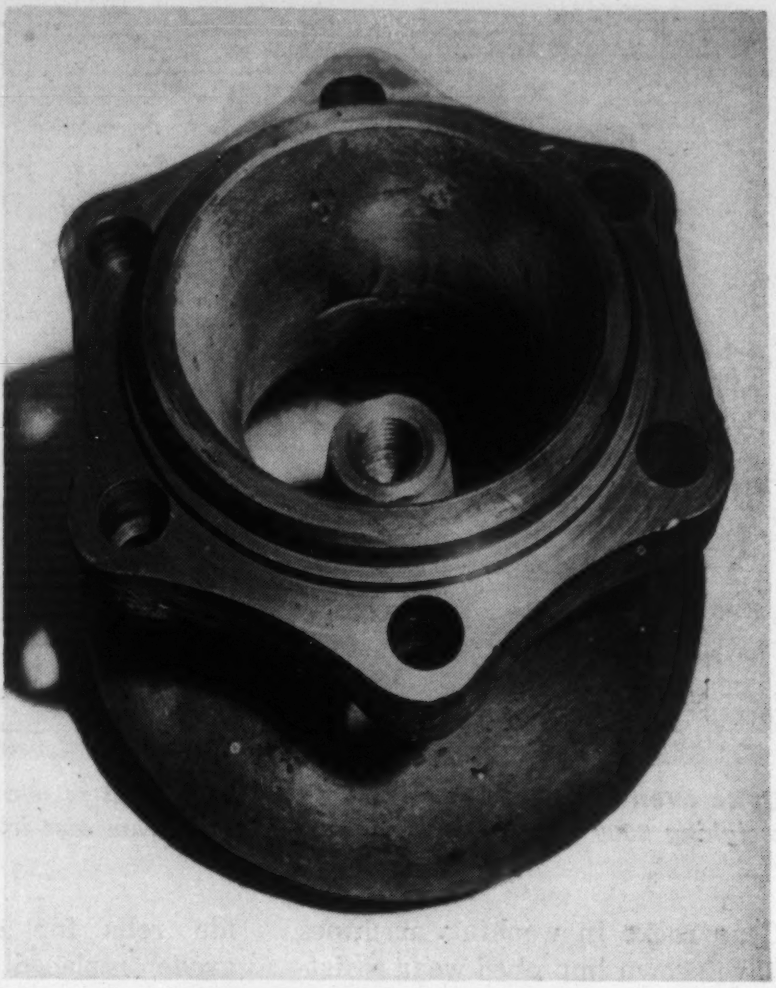
*Type 60-45-10* is characterized by maximum toughness and machinability. It can be welded almost as readily as the austenitic grade. Its major uses are in pressure castings and in shock resisting applications. Because of its higher strength, it has been used to replace malleable iron in hydraulic truck hoists for such parts as pistons and cylinder heads.

**TYPICAL APPLICATIONS**

| Type of Iron | Applications |
|---|---|
| 80-60-03 | Anvils for forging hammers, press side frames and beds, impellers, levers, crankshafts, cams, gears, rolls, dies, pistons, jet engine burner support rings |
| 60-45-10 | Valve and pump bodies, compressor heads and bodies, pipe fittings, clamps, gear housings, manifolds, motor frames, tractor and farm machinery parts |
| 100-75-04 | Track shoes, brake drums, gears, crankshafts and camshafts, pistons |
| 120-90-02 | Track rollers, tractor steering gear arms, pinions, gears, cams, dies, machine guides |
| Austenitic | Impellers, pumps and valves for handling corrosive solutions, grids, paper mill machine parts |
| Heat Resistant | Furnace doors and frames, grate bars, sinter pots, lead pots, glass molds and plungers, aluminum pouring troughs |



**Tire mold** *cast from ductile iron by Morris Bean & Co. Tolerance on 30-in. i.d. is held to ± 0.015 in. Blades in the tread design are stainless steel inserts.*



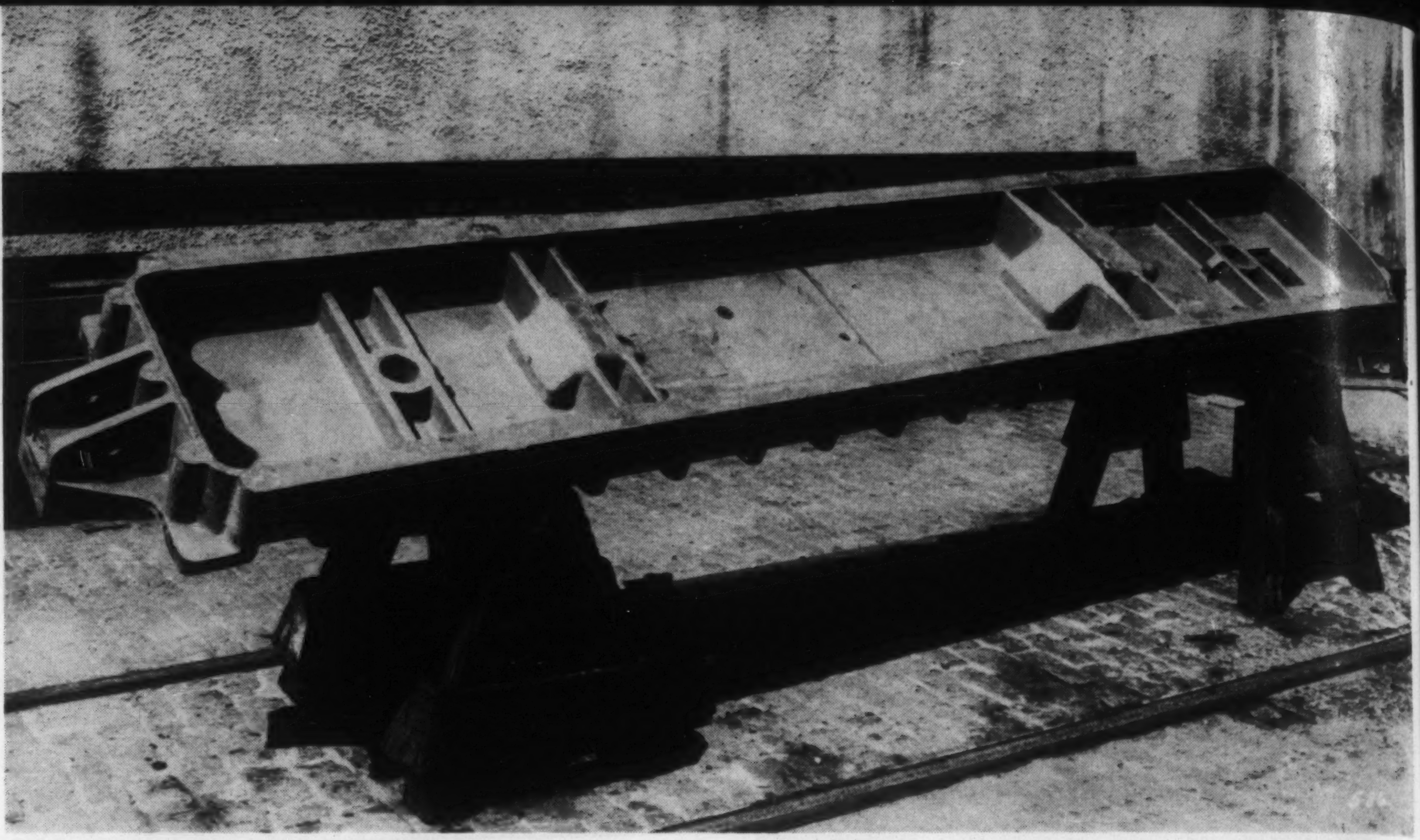
**Unloader body** *for compressor previously cast from steel for resistance to high pressures, now produced from S.G. iron.*

*(Cooper-Bessemer Corp.)*

**Propeller** *for industrial agitator cast from grade 60-45-10 by Lufkin Foundry & Machine Co.*

**Pivot shaft bracket** *for heavy duty trucks produced from annealed nodular iron by Vulcan Foundry Co.*

*(Meehanite Metal Corp.)*



**Coke oven furnace door** *produced from the heat resistant type of ductile iron. This door, 14 ft long and 2 ft wide, weighing 2500 lb, replaced a door fabricated from cast iron and steel.* (Koppers Co.)

Gear racks in washing machines have shown improved wear resistance when changed from forged low alloy steel to ductile iron 60-45-10. Other uses include butane manifold valve bodies for metering butane at high pressure, camshaft drive gears in labeling machines, tool shanks for carbide-tipped lathe tools, glass mold plungers and tire molds.

*Type 100-75-04* is usually normalized and tempered to develop a combination of strength, ductility and wear resistance. Ductile iron impellers of this grade used in boiler feed water pumps in a large power plant showed much greater resistance to cavitation than chromium stainless steel. This grade is also used for agricultural machinery parts, including bolsters, governor weights, reactor brake drums and track shoes, and for gears, crankshafts and camshafts.

*Type 120-90-02* is usually oil quenched and tempered to produce excellent wear resistance. In profile rolls for steel mills, this grade replaced steel and alloy gray iron and lasted 3 times as long as the other materials. Other applications include tractor steering gear arms, track rollers, pinions and gears, machine guides and dies.

The austenitic type is a highly alloyed iron containing about 20% nickel. With additions of 2.5% chromium, its elevated temperature strength compares with that of 18:8 stainless steel. It is non-magnetic and is the most readily weldable of the nodular irons. It is used in the chemical process industries for pumps and valves handling corrosive materials, in paper mills, in jet engine main bearing supports and also for service at elevated temperatures.

The heat resistant type contains a higher percentage of silicon than the other varieties. This type has the highest resistance to scaling of the group but, at the same time, the lowest room temperature ductility. Although it is not recommended for applications involving severe thermal shock, this type of ductile iron is used for such applications as annealing pots, aluminum pouring troughs, glass molds and plungers, blast furnace parts, coke quenching car parts, furnace doors and grate bars.

### *Acknowledgment*

The following organizations through their personnel and publications have assisted greatly in the preparation of this Manual:

Aetna-Standard Engineering Co.
American Brake Shoe Co.
American Cast Iron Pipe Co.
Cooper-Bessemer Corp.
Farrel-Birmingham Co.
Ingersol-Rand Co.
International Nickel Co., Inc.
Lufkin Foundry & Machine Co.
Meehanite Metal Corp.
Morris Bean & Co.
Treadwell Engineering Co.

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International Nickel Co.
Cooper-Bessemer Corp.
New Jersey Machine Corp.

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# MATERIALS ENGINEERING FILE FACTS

MATERIALS & METHODS • OCTOBER 1955 • NUMBER 306

## Standard Aluminum Automotive Alloys in United States and Great Britain

### WROUGHT ALLOYS

| Nominal Composition, % | Form | S.A.E. No. | Temper or Condition | B.S. No. | Temper or Condition |
|---|---|---|---|---|---|
| 99 Al | Sheet and Strip | 25 | O, H12, H14, H16, H18 | 1470–S1C | O, ¼H, ½H, ¾H, H |
| | Tubes | 25 | O, H14, H18 | 1471–T1C | O, H |
| | Rivets | 25 | F | 1473–R1C | M |
| | Extrusions | 25 | F | 1476–E1C | M |
| 1¼ Mn | Sheet and Strip | 29 | O, H12, H14, H16, H18 | 1470–NS3 | O, ¼H, ½H, ¾H, H |
| | Extrusions | 29 | F | — | — |
| 1¼ Mn, 1 Mg | Sheet and Strip | 20 | O, H32, H34, H36, H38 | — | — |
| | Tubes | 20 | F | — | — |
| 2 Mg | Sheet and Strip | 201 | O, H32, H34, H36, H38 | 1470–NS4 | O, ½H |
| | Tubes | 201 | O, H32, H34, H36, H38 | 1471–NT4 | O, ½H |
| | Extrusions | 201 | F | 1476–NE4 | M |
| 3½ Mg | Sheet and Strip | — | — | 1470–NS5 | O, ¼H |
| | Extrusions | — | — | 1476–NE5 | M |
| 5 Mg | Sheet and Strip | — | — | 1470–NS6 | O, ¼H |
| | Tubes | — | — | 1471–NT6 | O, ½H |
| | Extrusions | — | — | 1476–NE6 | M |
| | Wire and Rod | — | — | 1473–NR6 | M |
| 7 Mg | Tubes | — | — | 1471–NT7 | O, ½H |
| Cu-Mg-Ni | Wire and Rod | — | — | 1473–HR13 | M, T |
| Mg-Si | Extrusions | 282 | T4, T6 | 1476–HE9 | M, W, WP |
| Mg-Si-Cu-Mn-Cr | Sheet and Strip | 281 | T4, T6 | 1470–HS10 | W, WP |
| | Forgings | 280 | T6 | 1472–HF10 | W, WP |
| | Extrusions | 281 | T4, T6 | 1476–HE10 | W, WP |
| Cu-Mg-Si-Ni | Forgings | — | — | 1472–HF12 | WP |
| Cu-Mg-Mn | Sheet and Strip | 24 | O, T4, T36 | 1470–HS14<br>1470–HS15 | T<br>W, WP |
| | Clad Sheet and Strip | 240 | O, T4, T36 | 1470–HC14<br>1470–HC15 | T<br>W, WP |
| Cu-Mg-Mn | Extrusions | 24<br>26 | O, T4, T36<br>O, T4 | 1476–HE14<br>1476–HE15 | T<br>W, WP |
| Cu-Mg-Mn-Si | Clad Sheet<br>Extrusions<br>Forgings | 260 | T3, T4, T6 | — | — |
| Cu-Mg-Ni | Forgings | 270 | T6 | 1472–HF17 | WP |
| Si-Cu-Mg-Ni | Forgings | 290 | T6 | — | — |

### WORK HARDENING WROUGHT ALLOYS

| Old Designation | New S.A.E. Designations[1] | | | British |
|---|---|---|---|---|
| | Strain Hardened Only[2] | Strain Hardened and Partially Annealed[3] | Strain Hardened and Stabilized[4] | |
| ¼H (¼ hard) | H12 | H22 | H32 | ¼H |
| ½H (½ hard) | H14 | H24 | H34 | ½H |
| ¾H (¾ hard) | H16 | H26 | H36 | ¾H |
| H (hard) | H18 | H28 | H38 | H |
| F (as fabricated) | F | — | — | — |
| — | — | — | — | M (as manufactured) |
| — | — | — | — | O (annealed) |

---

[1] *The temper designation for annealed material of any alloy is O.*

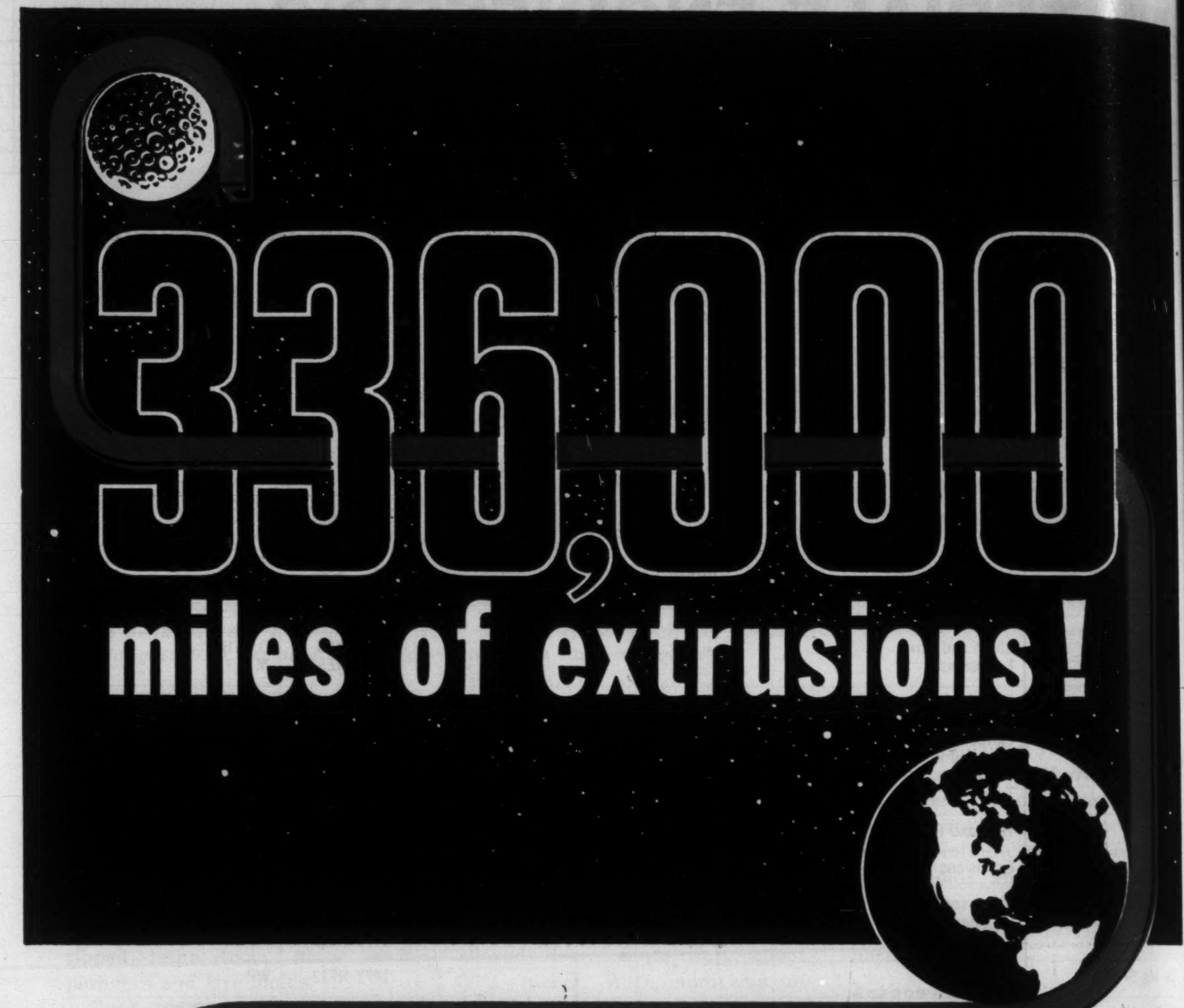
[2] *Standard tempers for S.A.E. 25 and 29.*

[3] *Not commercially standard*

[4] *Standard tempers for S.A.E. 20 and 201: these alloys also available in F temper.*

*(Continued on p. 139)*

◄ For more information, Circle No. 517



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# MATERIALS ENGINEERING FILE FACTS

MATERIALS & METHODS • OCTOBER 1955 • NUMBER 306

## Standard Aluminum Automotive Alloys in United States and Great Britain (con't)

### CASTING ALLOYS

| Nominal Composition, % | Form | S.A.E. No. | Temper or Condition | B.S. No. | Temper or Condition |
|---|---|---|---|---|---|
| 7 Cu, 3 Si, 3 Zn | Sand and Die | 33 | F | 1490-LM1 | M |
| 4.5 Cu, 1.5 Si | Sand | 38 | T4, T6, T62, T7 | — | — |
| 4.5 Cu, 2.5 Si | Gravity-die | 380 | T4, T6, T7 | — | — |
| 11 Si, 1.5 Cu | Pressure-die Sand | — | — | 1490-LM2 | M |
| 9 Si, 4 Cu | Pressure-die | 331 | T5, T6, T7 | — | — |
| 5 Si, 3 Cu | Sand and Die | 307<br>326<br>329<br>330 | F<br>F, T6<br>F, T6<br>F | 1490-LM4 | M |
| 5 Si, 1 Cu, 0.5 Mg | Sand and Gravity-die | 322 | T6, T51, T71 | — | — |
| 8 Si, 3.5 Cu | Pressure-die | 306<br>308 | F<br>F | — | — |
| 7 Si, 0.3 Mg | Sand and Gravity-die | 323 | T6, T51 | — | — |
| 8 Si, 1.5 Cu, 0.4 Mg, 0.4 Mn | Sand | 327 | F, T6 | — | — |
| 5 Mg | Sand and Die | 320 | F | 1490-LM5 | M |
| 12 Si | Sand and Die | 305 | F | 1490-LM6<br>1490-LM20 | M<br>M |
| 2 Cu, 2 Si, 1 Ni | Sand and Gravity-die | — | — | 1490-LM7 | M, P |
| 5 Si | Sand and Die | 35<br>304 | F<br>F | — | — |
| 9.5 Si, 0.5 Mg | Die | 309 | F | — | — |
| 5.5 Zn, 0.6 Mg, 0.5 Cr | Sand | 310 | T5, T51 | — | — |
| 10 Mg | Sand and Gravity-die | 324 | T4 | 1490-LM10 | W |
| 10 Cu, 2 Si, 0.2 Mg | Sand and Gravity-die | 34 | T2, T61, T551, T65 | 1490-LM12 | WP |
| 12 Si | Sand and Gravity-die | 321<br>328 | T551<br>T5 | 1490-LM13 | WP<br>WP Special |
| 4 Cu, 1.5 Mg, 2 Ni | Sand and Gravity-die | 39 | T21, T61, T571, T61 | 1490-LM14 | M, WP<br>WP Special |
| 2 Cu, 1.5 Si, 1.5 Ni | Sand and Gravity-die | — | — | 1490-LM15 | WP |
| 6 Cu, 5.5 Si | Gravity-die | 300 | T5 | — | — |
| 3 Cu, 9 Si, 1 Ni | Gravity-die | 332 | T5 | — | — |

### CONDITION OR TEMPER DESIGNATIONS
### CAST ALLOYS AND WROUGHT HEAT-TREATABLE ALLOYS

**S.A.E. Designation**

O—Annealed (wrought)
T2—Annealed (castings)
T3—Solution treated and cold worked (wrought)
T4—Solution heat treated
T5—Artificially aged only
T6—Solution heat treated and artificially aged
T7—Solution heat treated and stabilized
T8—Solution heat treated, cold worked and artificially aged
T9—Solution heat treated, artificially aged and cold worked
T10—Artificially aged and cold worked
F—As fabricated

**British Designation**

O—Annealed wrought alloy
M—As cast or as manufactured
W—Solution treated only
P—Precipitation treated (castings)
WP—Solution treated and precipitation treated
T—Precipitation treated air-hardening wrought alloy

*Adapted from Light Metals, Aug. 1954*

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# A New Kind of Rust-Preventive Primer

*A gel-like coating, it displaces the elements that cause rust, thereby eliminating the problem of underfilm corrosion.*

■ A new and unusual type of primer for steel is now available. It is entirely different from ordinary paints and is claimed to be much more effective in preventing rust on steel.

The new primer consists of a homogeneous black colloidal precipitate, thinned with a high-flash coal tar solvent. It dries solely by evaporation of solvent. Whereas a conventional primer produces a rigid pigmented film, the new primer produces a plastic, gel-like coating. The nature of the precipitate has not been disclosed, but it is said to result from "the chemical combination of ingredients, one of which is lead." Called "Blakled," the new primer was developed by Black Lead, Inc., and is being distributed by the U. S. Steel Supply Div.

### Three advantages

From a theoretical standpoint, Blakled offers three important advantages over conventional primers:

1. It has extremely high wetting power and therefore tends to completely saturate the steel surface.

2. Since the film is not rigid but plastic, it tends to "fill in" pores and crevices, thereby displacing air and moisture that might otherwise initiate corrosion. Absence of underfilm corrosion means that if the coating is damaged, rusting will be confined to that one area.

3. Because of its plasticity, its complete contact with the surface and its elimination of underfilm corrosion, the coating has excellent adhesion to the metal and no tendency to peel off.

From a practical standpoint, therefore, Blakled not only appears to offer better performance than conventional primers, but also requires less expensive surface preparation. Special surface treatments such as sandblasting or bonderizing can often be eliminated. Furthermore, since the coating displaces rust-producing elements, it can be applied to steel that is wet, rusty or mill-scaled.

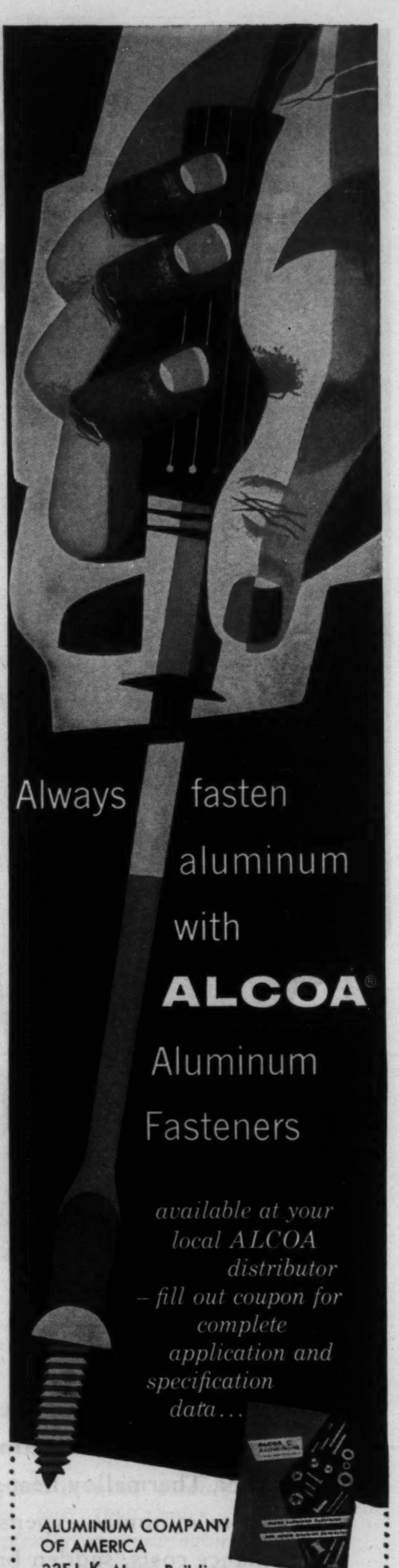
Blakled is compatible with most paints and, although it is said to have good atmospheric resistance, it is generally used as a primer for a conventional top coat that may provide good resistance to an acid, alkali, salt spray or other atmosphere. Such a combination is particularly useful since many of the most corrosion-resistant paints have relatively poor adhesion to metals. In some cases, the adhesion of such a paint can be improved by mixing in Blakled, but the adhesion of the resulting coating is not as great as that of Blakled alone.

Since the effectiveness of a Blakled coating depends upon its "filling in" ability, it offers no advantage as a top coat. However, it can be applied over an old paint film that has largely peeled off.

### Brush or spray

Blakled air-dries to the touch within an hour, and a top coat can be applied shortly thereafter. The primer can be applied by spray, brush or dip. Spraying is particularly easy because of the homogeneity of the primer. When applied by brush, the primer is merely "spread on," rather than "brushed out." Brush and spray units may be cleaned easily by rinsing in mineral spirits, turpentine or naphtha. Since it is a colloid, Blakled does not separate in the container and does not form a skin over the top when the container has been opened. It therefore requires only a minimum of preparation before being applied.

The new primer is available only in black. Since it is chemically inert, it will not "bleed" through a white or colored top coat. Blakled's cost per gallon is reported to be "comparable to and in many cases less than" the cost of other rust-inhibitive paints, such as red lead.



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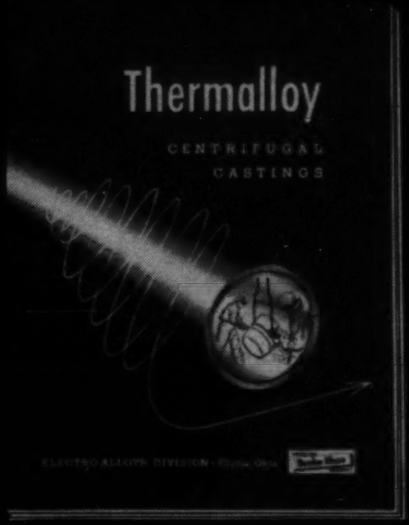
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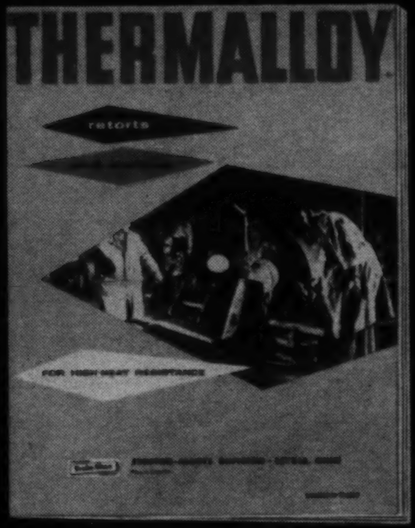
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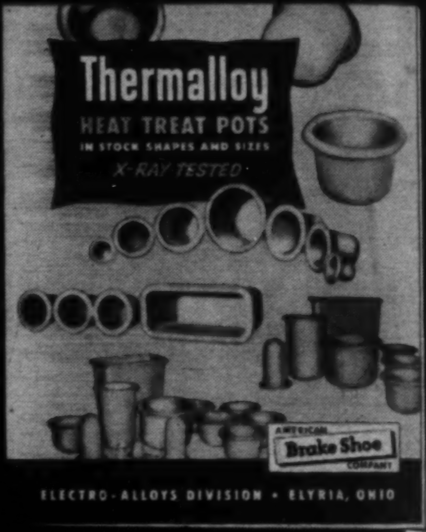
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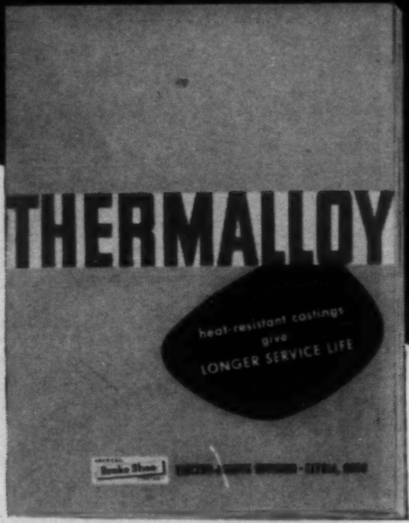
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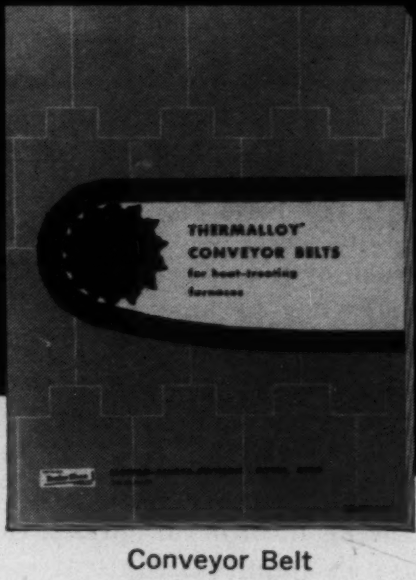
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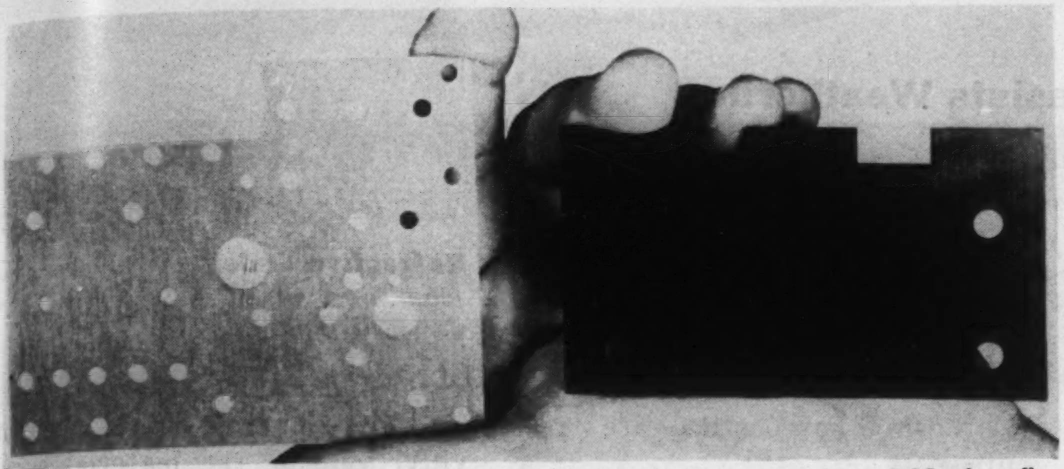
# New Materials, Parts and Finishes | and related equipment



***Precision cold punching** is illustrated by these two samples of National's XXXP-470 Phenolite.*

## Cold Punching Laminate for Printed Circuits

An electrical grade phenolic laminate which can be punched at room temperature has been marketed by *National Vulcanized Fibre Co.*, 1055 Beech St., Wilmington 99, Del. The laminate, Grade XXXP-470 Phenolite, is said to be particularly suited for use in copper-clad printed circuits where automatic processes require close registration of punched mounting holes for component inserters. The accompanying table lists typical properties of the material, both bare and copper-clad.

The laminate is available in the same thickness range, tolerance and sheet sizes as the company's other XXXP grades. Properties such as insulation resistance and electrical loss are said to match or exceed those of National's hot punching grades.

Copper clad bond strength and hot solder dip properties of the new laminate are comparable to those of other copper clad grades in the same line.

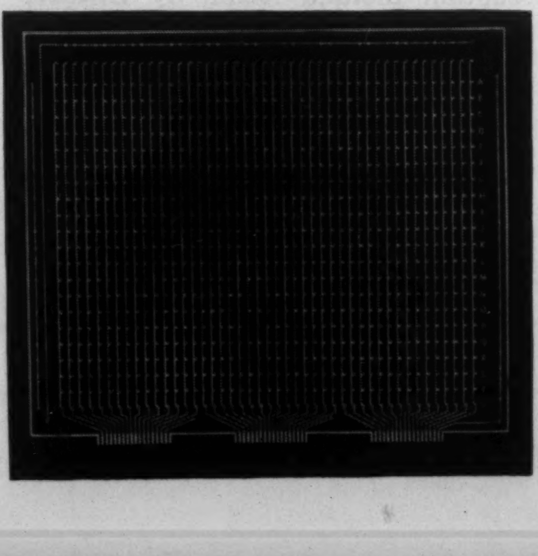
In the new automatic methods of producing printed circuits involving larger boards, precise spacing of punched holes is imperative. According to National, all Grade XXXP phenolic laminated plastics had to be hot punched until the development of their new product. Expansion of heated sheets along their length differs from expansion across their width and varies with materials involved, making it difficult to hold dimensional tolerances. The new cold punching laminate is said to solve this problem.

National warns, however, that the designer should bear in mind that in order to achieve good cold punching characteristics, the new laminate has lower flexural strength and higher cold flow than other XXXP grades.

**TYPICAL PROPERTIES OF GRADE XXXP-470 PHENOLITE**

| Property | Typical Values (1/16 in. thick sheet) | |
|---|---|---|
| | XXXP-470 | NEMA Standard |
| Flex Str, psi | | |
| MD | 14,100 | 12,000 |
| CD | 11,600 | 10,500 |
| Water absorp, % (D-24/23) | 0.48 | 1.00 |
| Dis factor, $10^6$ cycles | | |
| Cond A (as received) | 0.268 | 0.030 |
| Cond D-24/23 | 0.281 | 0.035 |
| Diel const, $10^6$ cycles | | |
| Cond A (as received) | 3.75 | |
| Cond D-24/23 | 3.83 | |
| Hardness, 75 F, Rm | 94 | |
| Cold flow, division change, div. | 43.0 | |
| Insul resist, megohms* | | |
| Cond A (as received) | 1,000,000 | |
| Cond D-24/23 | 900,000 | |
| Density | 1.27 | |
| Properties of Copper Clad XXXP-470 Phenolite | | |
| Bond str, lb/in. of strip | | |
| with 1-oz copper | 5 | |
| with 2-oz copper | 6 | |
| Dip solder test, sec (1 x 1 in. specimen) | | |
| at 446 F | 27 | |
| at 464 F | 12-21 | |
| at 482 F | 8-13 | |

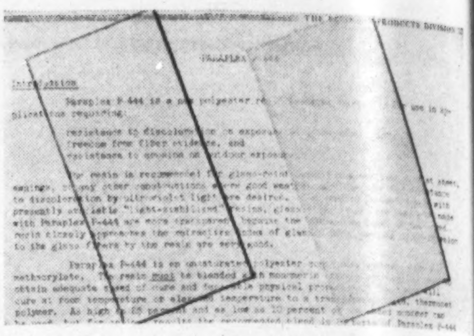
** 11/16 x 1-1/8-in. specimen with 3/16-in. holes on 1/2-in. centers.*



***Typical printed circuit** for computer has 1000 holes, indicating complexity of manufacture.*

# New Materials, Parts and Finishes | and related equipment

## Transparent Polyester Resists Weathering



**Refractive index** *of panels made from new resin (left) closely approaches that of glass.*

A new polyester resin, Paraplex P-444 has been developed by *Rohm & Haas Co.*, Washington Sq., Philadelphia 5. The new resin will produce glass fiber-reinforced laminates with greater transparency than previously possible with conventional resins. In recommended blends of 80 parts P-444, 20 parts monomeric styrene or vinyl toluene, the average refractive index of the cured material is 1.546, as compared with 1.548 for glass. The resin is designed particularly for use in applications requiring resistance to discoloration by ultraviolet light, freedom from fiber evidence and resistance to erosion on outdoor exposure. It is recommended for use in glass-reinforced corrugated panels, flat sheet, awnings or other constructions where good weathering properties are required.

An unsaturated polyester containing monomeric methyl methacrylate, the new resin must be blended with from 10 to 25% monomeric styrene or vinyl toluene to obtain adequate speed of cure and desirable physical properties. Combined with styrene or vinyl toluene, the material cures in a manner similar to conventional polyester resins. It should be handled as such with respect to catalysts, catalyst concentrations and curing cycles. Pigments, dyes or both may be added to produce a colored polymer.

## Cold Curing Agent for Epoxy Paints

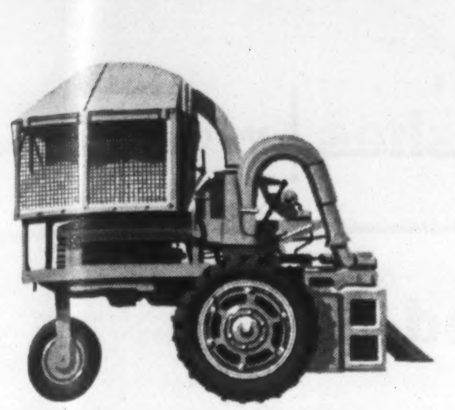
A new cold curing agent C-111 is said to hold promise for extending use of catalyzed epoxy resin-based paints. Paints cured with it at room temperature exhibit film properties normally achieved only in baked surface coatings. Developed by *Shell Chemical Corp.*, 50 W. 50th St., New York 20, curing agent C-111 is said to have two advantages over the widely used aliphatic polyamines: 1) It reduces or eliminates "curing agent blush" on films cured under conditions of high humidity, and 2) it gives a high rate of cure at temperatures as low as 35-40 F. It is also said to impart slightly better physical properties to Shell's Epon (epoxy) resin-based coatings than does diethylene triamine. The new curing agent is now available in trial lot quantities.

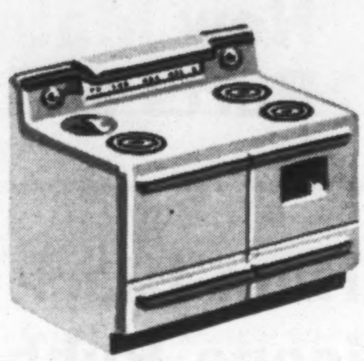
## New Elastomers Resist Chemicals

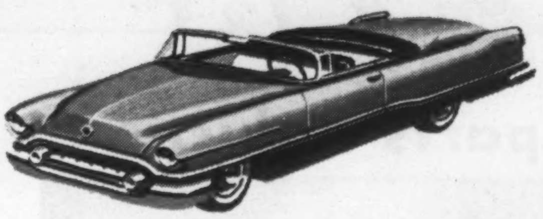
A new compound will provide O-rings and other molded items with exceptional resistance to swelling and shrinking in many normally destructive organic fluids. It is being marketed as custom molded items by *Linear, Inc.*, State Rd. & Levick St., Philadelphia 35. The basic polymer from which the material, WJ-70, is made is dihydroperfluorobutlacrylate, commonly referred to as poly FBA, manufactured by *Minnesota Mining and Mfg. Co.* Linear's formulation is suitable for service in temperatures from —20 to 350 F and has a low compression set, making it suitable for use in O-rings and V-rings. Also, its flexing characteristics and suitability for fabric impregnation make the formulation quite useful for diaphragms.

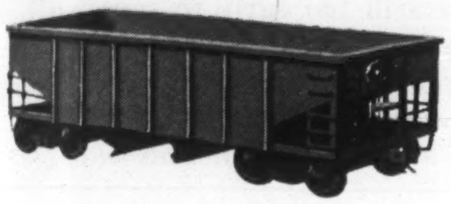
Laboratory tests indicate that WJ-70 shows little change in properties after immersion in diester fluids for periods in excess of one month at temperatures of 350 F, making it suitable for use in MIL-L-7808, aircraft gas turbine engine oil. The compound is said to have high dimensional stability in such fluids as Arochlor, Dow-Therm A, Pyranol and many halogenated solvents, and is suitable for use in Pydraul, tricresyl phosphate and other organic phosphates, as well as carbon tetrachloride, chlorobromomethane and ethylene dichloride. Even when these fluids become contaminated by lubricating oils the compound maintains molded dimensions because of its resistance to swell in mineral base oils. Seals made of the compound have been dynamically cycled for over 50,000 cycles without failure in fluids at temperatures up to 500 F with over 3000 psi pressure.

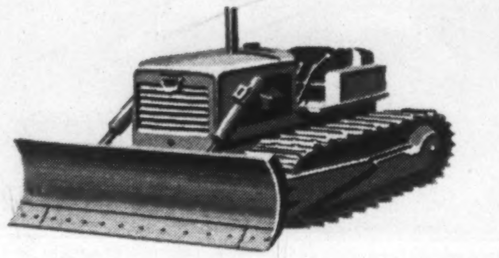
*(More New Materials on p. 146)*

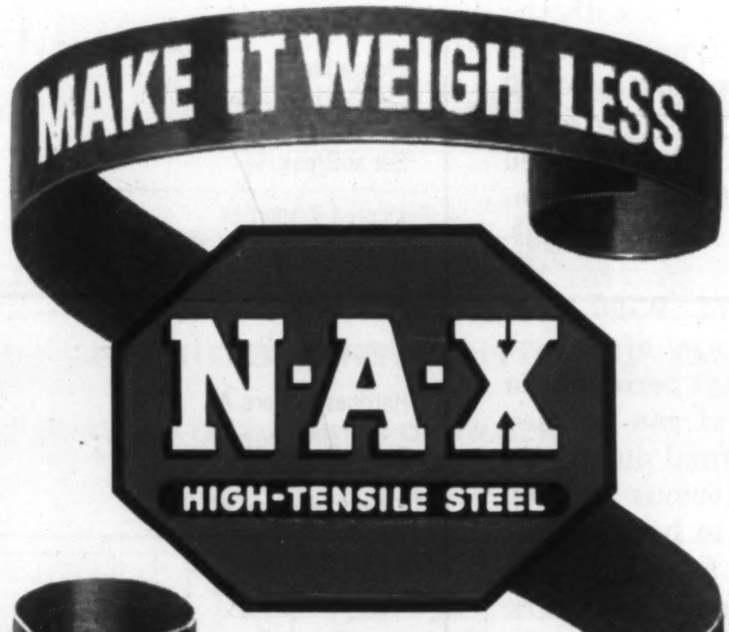












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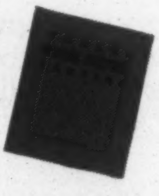

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# New Materials, Parts and Finishes | and related equipment

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## Carbon Black Filled Silicone Rubber

A silicone rubber gum stock which can be filled and reinforced with carbon black is being produced by *Linde Air Products Co., Silicones Dept.*, 30 E. 42nd St., New York 17. As yet the full potentials of the material are not known; however, it seems evident that new uses previously beyond the reach of silicone rubber may be possible. According to Linde, electrically conductive silicone elastomers are one such possibility. The gum stock is one which Linde announced earlier this year, W-96, which when filled with the conventional silica type materials provides a compression set of 12 to 20% of original deflection after 22 hr at 350 F. It has controlled reactivity inherent in the gum stock itself, which greatly simplifies processing.

Characteristics of W-96 gum stock permit the use of a new catalyst, di-tert-butyl peroxide, in curing. The catalyst can be used in smaller than normal quantities and leaves no deleterious residue. It has been found to be the most effective catalyst for use with black-filled W-96 compounds. The recommended loading is 2 parts di-tert-butyl peroxide to 100 parts W-96, followed by a mold cure of 25 min at 340 F and a post-cure of 25 min at 300 F. The accompanying table lists typical properties of a compound containing 100 parts W-96, 40 parts carbon black and 2 parts di-tert-butyl peroxide. The catalyst is available from Shell Chemical Corp., and Lucidol Div. of Wallace and Tiernan Co., Inc.

Major differences between mechanical properties of black-filled compounds and those of a silica reinforced W-96 compound lie in heat resistance at 450 F and in compression set. The ease with which silica fillers and carbon blacks can be co-blended into the gum stock allows physical properties to be varied between the two extremes. According to Linde, it is still too early to say just how broad the possibilities for the new gum stock are. Only further experimental work will tell.

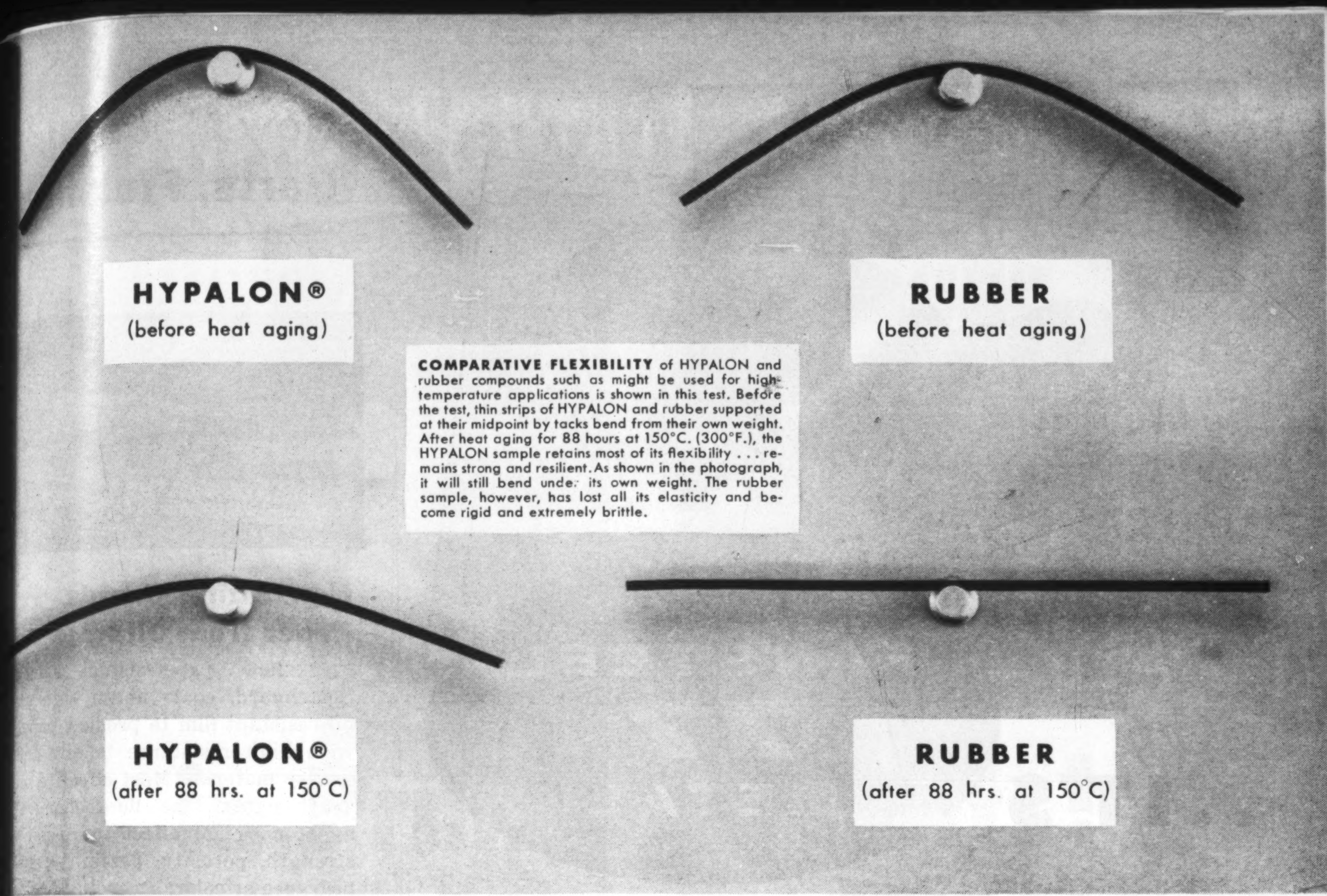
*(More New Materials on p. 148)*

**TYPICAL PROPERTIES OF BLACK-FILLED W-96 COMPOUND**[1]

| | |
|---|---|
| (Mold Cure Properties<br>Mold Cure 25 min at 340 F) | |
| Tensile, psi | 910 |
| Elongation, % | 350 |
| Hardness, Shore A | 44 |
| Set at Break, % | 5 |
| Postcured Properties<br>(Oven Cured 24 hr at 480 F) | |
| Tensile, psi | 750 |
| Elongation, % | 270 |
| Hardness, Shore A | 54 |
| Set at Break, % | 10 |
| Total Shrinkage, % | 13 |
| Dry Heat Resistance[2]<br>(At 350 F after 24 hr) | |
| Tensile, psi | 930 |
| Elongation, % | 360 |
| Hardness, Shore A | 48 |
| (At 450 F after 24 hr) | |
| Tensile, psi | 840 |
| Elongation, % | 340 |
| Hardness, Shore A | 50 |
| Compression Set<br>(Method B; % of Orig Defl) | |
| 22 hr at 300 F | 47 |
| 70 hr at 300 F | 63 |
| Brittle Point, F<br>(ASTM D746-52T) | <−90 |

[1] *Carbon black used was Philblack O.*

[2] *Dry Heat Resistance run on mold cured samples. All other data are based on samples with postcure of 24 hr at 480 F.*



**COMPARATIVE FLEXIBILITY** of HYPALON and rubber compounds such as might be used for high-temperature applications is shown in this test. Before the test, thin strips of HYPALON and rubber supported at their midpoint by tacks bend from their own weight. After heat aging for 88 hours at 150°C. (300°F.), the HYPALON sample retains most of its flexibility . . . remains strong and resilient. As shown in the photograph, it will still bend under its own weight. The rubber sample, however, has lost all its elasticity and become rigid and extremely brittle.

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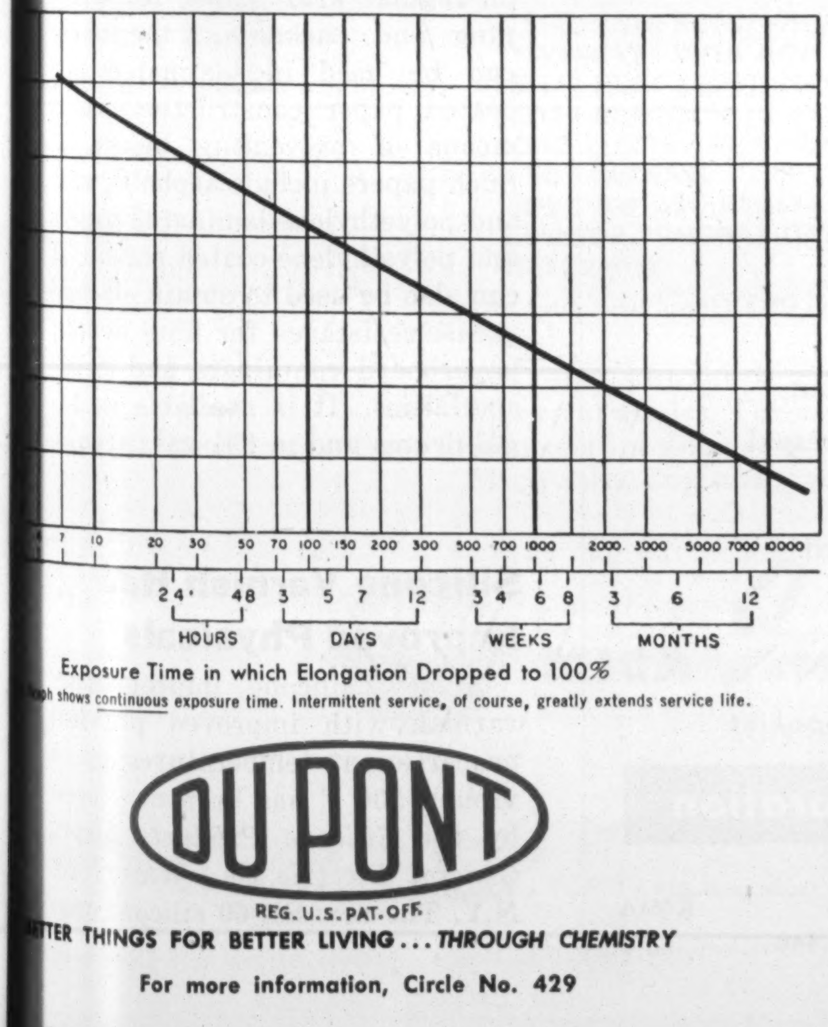

ph shows continuous exposure time. Intermittent service, of course, greatly extends service life.

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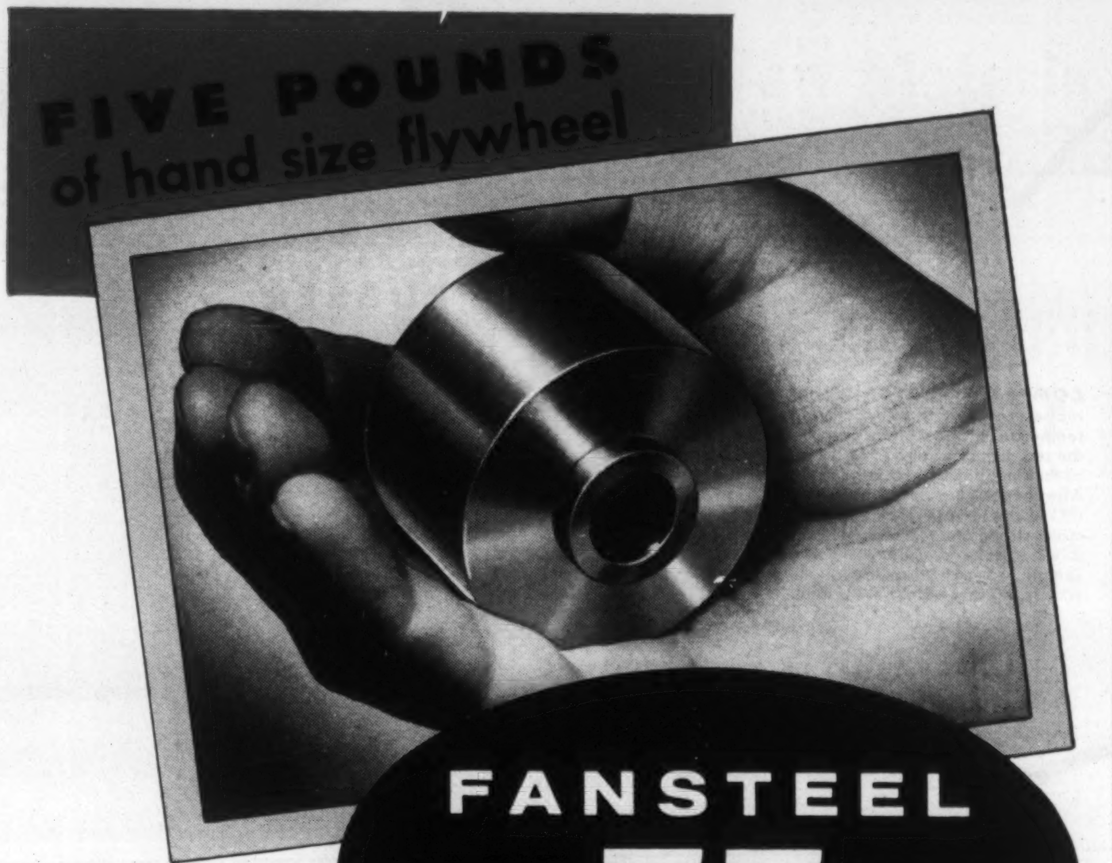

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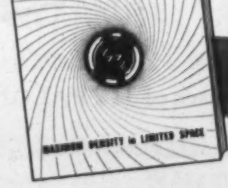
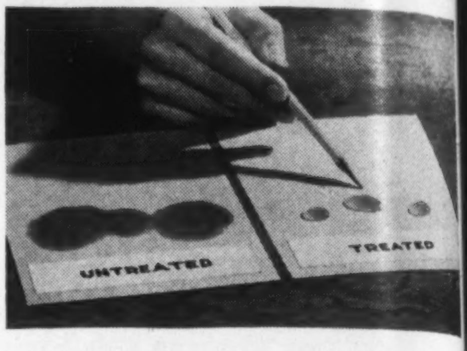


# New Materials, Parts, Finishes



## New Sizing Guards Paper from Oil

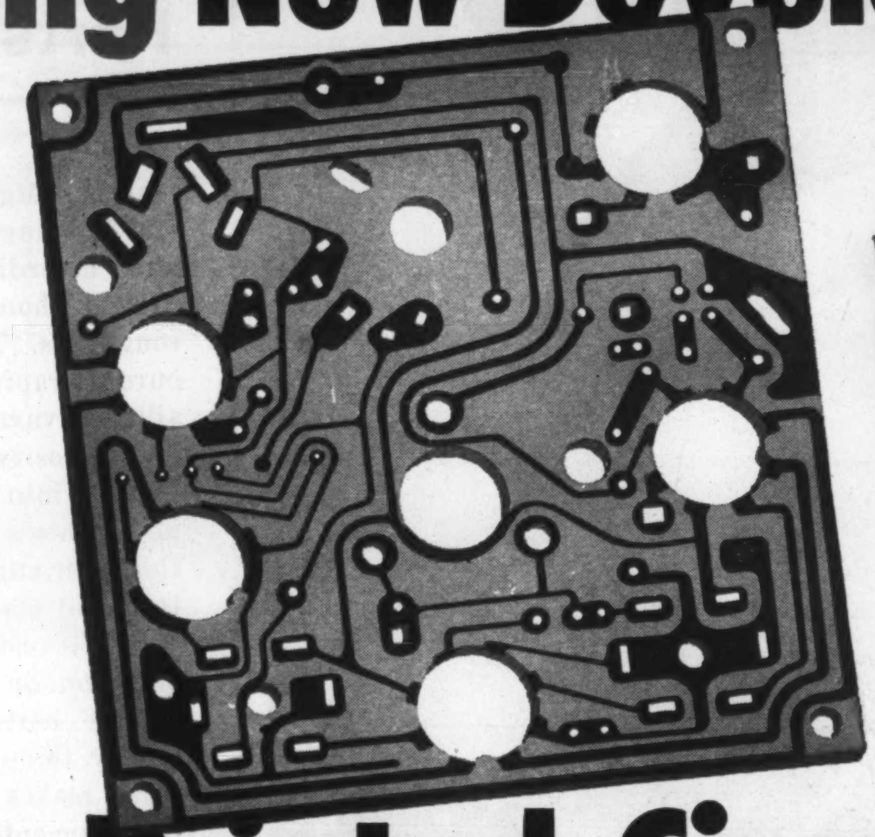
A new paper-sizing agent, Scotchgard, coats fibers with an oil-resistant film to produce paper with high resistance to oily and greasy material. Most effective on kraft paper, the fluorochemical agent does not affect the paper's strength, porosity, flexibility, appearance or color, according to the manufacturer, *Minnesota Mining and Mfg. Co.,* 900 Fauquier St., St. Paul 6, Minn.

The material is used in a water solution and is sprayed on the moving web of paper or applied as it passes through the size press. It can be used in most paper production lines with existing equipment. In addition to being used on regular kraft paper for wrapping and packaging, the agent can be used in laminated and coated paper constructions as a means of preventing bleedback. Such papers include asphalt-, wax- and polyethylene-laminated papers and polyethylene-coated papers. It can also be used to obtain oil- and grease-resistance for fibre drums, paperboard containers and paper specialties. It is available in 14-gal drums and in 6½-gal carboys.

## Silicone Varnish Has Improved Physicals

A new silicone impregnating varnish with improved physical properties at temperatures up to around 500 F has been developed by the *Silicone Products Dept., General Electric Co.,* Waterford, N.Y. The new SR-60 silicone var-

# Exciting New Development



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**BOND STRENGTH**—Guaranteed min: 6 lb.; avg. 9 lbs. (90° peel at 2 lbs/min.)

**SOLDER TEST**—Guaranteed no blisters @ 230-240° C. for 10 seconds, 1" square floated on molten solder

**HEAT RESISTANCE**—Guaranteed no change at 150° C. for ½ hour in air-circulated oven, air flow parallel to specimen

**PUNCHABILITY**—Excellent

**SURFACE RESISTIVITY**, megohms
C-96/35/90 .......... $7.3 \times 10^4$

**VOLUME RESISTIVITY**, megohm cm.
C-96/35/90 .......... $3.7 \times 10^5$

**WATER ABSORPTION**
1/16" th., E-1/105 + D-24/23
copper on .......... 0.1%
1/16" th., E-1/105 + D-24/23
copper removed .......... 0.7%

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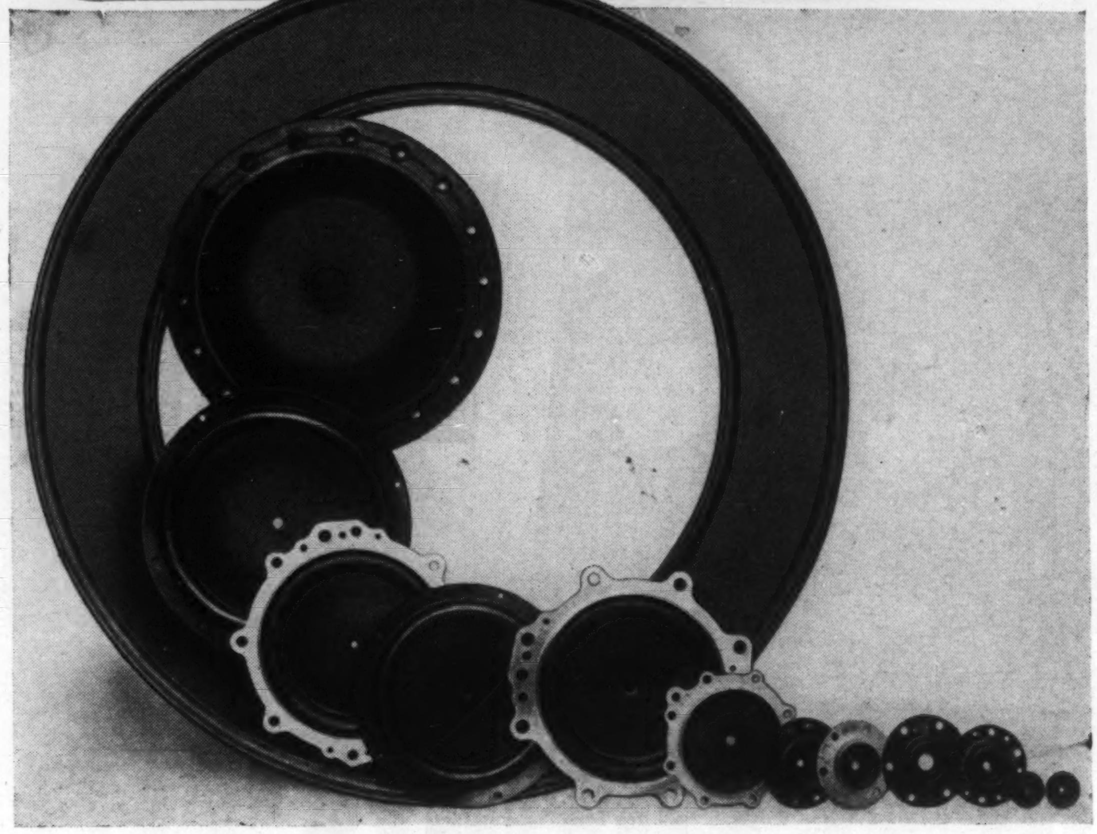

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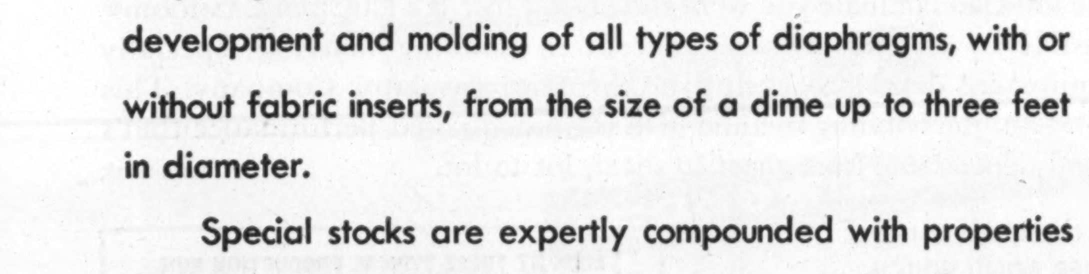

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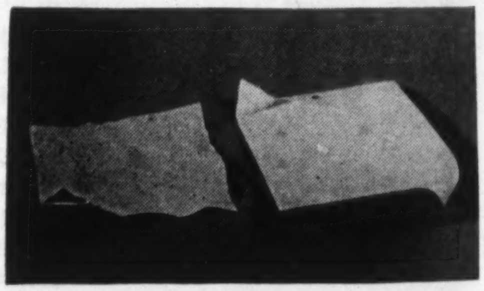
nish is designed for impregnating and bonding electrical equipment and, according to G-E, has improved bonding strength and toughness. The resin is said to cure as rapidly at 300 F as other silicone varnishes at 500 F. Its low viscosity provides good penetration into electrical equipment and shows less weight loss than conventional varnishes when tested at 500 F.

SR-60 resin is designed for application on Class H equipment (356 F hottest spot), though its ability to cure at lower temperatures makes it suitable for Class B equipment (266 F hottest spot). The resin was developed for impregnating and bonding such equipment as stator and armature coils, aircraft generators, dry-type transformers and glass asbestos served wire. According to G-E, on Class B equipment the resin permits such improvements in performance as additional thermal protection when applied atop motor and transformer coils.



## Epoxy Coating Guards Metals

A new epoxide finish which can be applied directly to any clean metal surface is said to provide a hard surface with excellent adhesion while remaining flexible enough so that it will not crack or chip under impact or bending. Called Poly-Ep Platon, the material is a two-component finish that is mixed in equal parts as required, and can be applied by brush, spray, applicator or dipping. It was developed by *Minne-*

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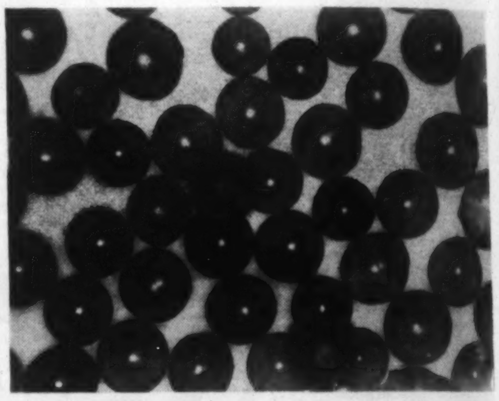
*sota Platon Corp.,* Pipestone, Minn. When mixed, the coating material has a low viscosity which is maintained in the container for several hours with little change. When applied, however, it air dries dust-free in 30 min and can be handled in 120 min. Forced drying for 30 min at 130 F produces a hard, free-sanding surface. Reports indicate that the material exceeds federal paint specifications TTE 487B Olive Drab Rust Inhibitive Enamel. It is available clear or in colors, with a glossy or satin finish.



***Photomicrograph*** *(75x) shows construction of tiny clay spheres.*

## New Ceramic Filler for Plastics

An inorganic filler material consisting of unicellular clay spheres, fired at about 3000 F is being produced for use as filler for casting resins, as a core filler in plastics dies and as a strength additive in foamed plastics. Originally developed by the Kanium Corp. in cooperation with Armour Research Foundation, the material called Kanamite is being commercially produced by *Ferro Corp., Kanamite Div.,* 4150 E. 54th St., Cleveland 5. In effect, the particles are small, hollow glass spheres ranging in diameter from 150 to 850 microns. About 91% pass a 28 mesh screen and are retained on a 60 mesh screen. Bulk density is 29 lb per cu ft, though lighter densities to 15 lb per cu ft are

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Strippable Coating
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So tough, the dried film maintains a tensile strength of over 3,000 pounds per square inch...and yet it's easy to remove by simply "peeling off." When the film is removed, the finished product will reveal its original lustre and color . . . completely free from scratches, smudges and defects!

SPRAYLAT SC-1071B is the perfect guarantee for top production and extra economy for you. It's your assurance that your product will be installed "Factory Fresh" ...will look as you want it to look. We'll be glad to send you a bulletin fully describing SPRAYLAT.

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## New Materials, Parts, Finishes

feasible providing they are in demand.

As well as being useful as an inorganic displacement filler in plastics, Kanamite is said to increase flowability and, in proper proportions, can add strength. The material can also reduce shrinkage of resins during cures. It is said to be well suited for use in plastics core materials for building panels, flotation materials and cores for dies. Long range possibilities may lie in ceramic and lightweight concrete products.

### Variable Density Dielectric Foams

A new series of foamed plastics materials called Eccofoam Hi K is said to combine high dielectric constant and low weight. Produced by *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass., the material is said to have a low dissipation factor and is usable from −65 to 275 F. It is presently available as sheet stock which can be machined, or as custom molded shapes of exact dimension. Range of dielectric constants possible with several bulk densities are as follows: 5 lb per cu ft, 1.1 to 4.0; 10 lb per cu ft, 1.2 to 7.0; and 15 lb per cu ft, 1.3 to 10.0.

*(More New Materials on p. 156)*

SPRAYLAT
COVERLAC SC-224
Strippable Coating
for: METAL SURFACES

You can achieve greater economy . . . and greater protection . . . with COVERLAC SC-224. Unequalled in its strength, pliability and "stripping off" qualities, it means the end to costly rejections and refinishing.

Easily sprayed on, COVERLAC offers complete protection against abuse during such procedures as blanking, drilling, routing, form rolling, riveting, shipping and even storage up to one year! After installation this tough durable coating may be quickly "peeled off" revealing an original "Fresh-From-the-Factory" look. Included among its many uses are the protection of stainless steel, chrome and nickel platings, vitreous enamels, and glass.

Why wait any longer to find out more about COVERLAC's economical protection against physical damage? Mail the coupon below today...We'll be glad to send you a FREE bulletin fully describing COVERLAC.

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"One day we were using **14** hand sprayers ...the next day, **2**

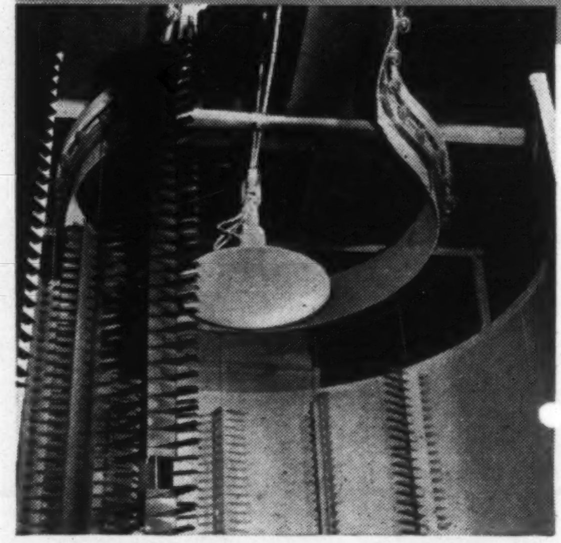
"One day we were using **180** gallons of paint ...the next day, **75**

"Fantastic?" **Not exactly. It's a typical, on-the-job-example of the savings made possible with the**

**RANSBURG NO. 2 PROCESS**

Electrostatic Spray Painting

**And, in this instance* production was increased; quality of the work improved, and rejections cut to practically nothing.**



*Fluorescent Fixtures of California, in their modern plant in South San Francisco, uses the Ransburg No. 2 Process Reciprocating Disc Atomizer to paint their popular line of ALL-BRITE lighting fixtures. The quotes above are from Works Manager, R. H. Shaffer.

Regardless of the type of product you manufacture, if it's painted . . . and, if your production justifies conveyorized painting, you should look into the savings (and improved quality) which can be yours with one of the Ransburg Electrostatic Painting Processes. May we tell you about complete Ransburg services?

Write Dept. M

Ransburg **ELECTRO-COATING CORP.**
**Indianapolis 7, Indiana**

RANSBURG

**For more information, turn to Reader Service Card, Circle No. 360**

# New Materials, Parts, Finishes

## New Acrylic Electrical Insulation

A new acrylic electrical insulation makes it possible to use potentially inexpensive, chemically identical insulating material throughout a piece of electrical equipment. Lectron acrylic resin wire enamel, glass fabrics coated with the resin, and laminates of the coated glass fabric will withstand temperatures for extended periods above the minimum required for Class B insulation (266 F). They can be used intermittently at temperatures up to 300 F. Dielectric properties of the materials are essentially unaffected by high relative humidity. They are available in pilot plant quantities from *Fabrics and Finishes Dept., E. I. du Pont de Nemours & Co.*, Wilmington, Del.

Glass fabric coated with Lectron is available in experimental quantities in a 3-mil construction, 38 in. in width, at $1.41 a yard. Laminates of various thicknesses are available for evaluation as slot liners, top sticks, and coil separators. Lectron enamel can be applied to various glass fabric constructions as well as to fabrics woven from other materials.

## Nylon Paper Commercially Produced

The first commercial run of synthetic paper made wholly from nylon fiber has been produced by *Riegel Paper Corp.*, 260 Madison Ave., New York 16. The paper has high tear strength and is many times stronger than paper made with rags or wood pulp. It is highly resistant to chemical attack, absorbs little moisture and resists action of molds, bacteria and light. Applications for the material would seem to lie in heavy duty bags, filtration of corrosive liquids and chemicals, and

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Photograph courtesy The Kleer-Flo Co., New York, N.Y.

NIALK TRICHLORethylene is one of the most efficient of all metal cleaning and degreasing agents.

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**60 East 42nd Street, New York 17, N. Y.**

*Plant: Niagara Falls, N.Y.*

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*(Advertisement)*

# Tempilstik°

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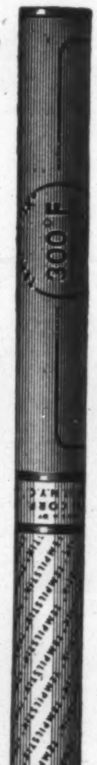
**HEAT-DEPENDENT**

**OPERATIONS**

*looks like a crayon... marks like a crayon... tells temperatures like a precision instrument!*



Sixty-three different compositions enable you to determine and control working temperatures from 113° to 2000° F.

TEMPILSTIK° marks on workpiece "say when" by melting at stated temperatures—plus or minus 1%.

Also Available
in Liquid and Pellet Form
...Write Industrial Div.
For Sample Tempil° Pellets
. . . State Temperatures of
Interest—Please!

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**CORPORATION**

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NEW YORK 11, N. Y.

# How Tempilstiks° are used

● TEMPILSTIKS° are temperature-sensitive crayons of calibrated melting points. There are some sixty-five different TEMPILSTIKS° in the range from 113°F to 2000°F, each indicating a specified temperature, within a tolerance of plus or minus 1% of its rating.

The appropriate TEMPILSTIK° is selected and, for most applications, the work-piece is marked with it before heat is applied. On subsequent heating the crayon-like mark of the TEMPILSTIK° melts as soon as its temperature rating is reached.

The mark made by a TEMPILSTIK° may gradually change in color as heating progresses. The change in color, or in color intensity, is never to be interpreted as a temperature indication. The TEMPILSTIK° mark melts when its temperature rating is reached and only this change from the dry to the liquid condition is the significant temperature signal.

In some applications this simple method may not suffice because evaporation of the TEMPILSTIK° mark on prolonged heating, or its gradual absorption by the surface at high temperatures, may leave too little residual substance for unambiguous observation. In such cases stroking or touching the work-piece with the TEMPILSTIK° at regular intervals during the heating process is recommended. The TEMPILSTIK° will leave a dry mark at temperatures below its rating and a liquid streak when its temperature rating has been reached or exceeded. If the workpiece is not accessible for applying a TEMPILSTIK° during the heating process, then TEMPILAQ°, or possibly TEMPIL° PELLETS, should be used instead.

TEMPILSTIKS° will usually glide over unheated polished surfaces (like glass, polished stainless steel, etc.) without leaving an appreciable mark. Therefore, in applications that involve smooth or polished surfaces TEMPILSTIKS° should be used by touching or stroking the workpiece periodically during the heating process, as previously described, because a liquid streak will be made on contact as soon as the specified temperature is reached. Where it is necessary to mark a smooth work piece surface prior to heating, TEMPILAQ° should be used.

A hot radiating surface will appear relatively dark under intense illumination from an external source, and this fact can be utilized to improve recognition of the temperature signal against a red-hot background. The use of TEMPIL° PELLETS or TEMPILAQ° instead of TEMPILSTIKS° will further improve visibility under these conditions.

On rapidly moving objects, like magnesium or aluminum sheet during spinning operations, it is impossible to see whether the applied TEMPILSTIK° leaves a dry or melted mark. However, with a little experience operators quickly learn to sense the smooth gliding of a TEMPILSTIK° over a surface which is hot enough to melt it on contact, as contrasted to the frictional drag on a cooler surface. If the top of the TEMPILSTIK° is brought in contact with the moving metal surface for a brief moment at a time, and with light pressure only, the heat contribution of friction is trivial enough to be ignored.

The above described "sensing technique" may also be employed on hot radiating surfaces where the bright background makes it difficult to distinguish whether or not the TEMPILSTIK° mark had melted.

An appropriate series of TEMPILSTIK° marks, applied to the workpiece or surface under investigation before heating begins, will provide a record of the maximum temperature attained during a process or operation. Subsequent examination will show that all TEMPILSTIK° marks up to a certain temperature rating had melted, while those of a higher rating had not. The maximum attained temperature must consequently lie somewhere in the interval between the highest melted and the lowest unmelted TEMPILSTIK° rating.

The temperature distribution and isothermal boundaries of surfaces such as furnace walls, melting ladles, cement kilns, etc., can be established by using an appropriately chosen series of TEMPILSTIKS° to draw a pattern of lines (parallel, concentric, radial, etc.) on the area under investigation. The heat conduction along a surface can be effectively studied by the progressive melting of suitably chosen TEMPILSTIK° lines. Caution must be exercised not to permit the mark made with one TEMPILSTIK° rating to cross or overlap the mark of a dissimilar TEMPILSTIK°, as such a mixing of different TEMPILSTIK° marks would destroy their accuracy.

TEMPIL° products will give good results in induction heating and in ionized air, as well as in the presence of static electricity about electrical equipment, where electrical means of measuring temperatures often function erratically.

**Visit us at Booth 1533—Oct. 17-21—Nat'l Metal Exposition—Philadelphia**

**For more information, turn to Reader Service Card, Circle No. 448**

# New Materials, Parts, Finishes

in map and tracing papers for important records and documents. Though present production costs are high they are expected to decrease as production increases.

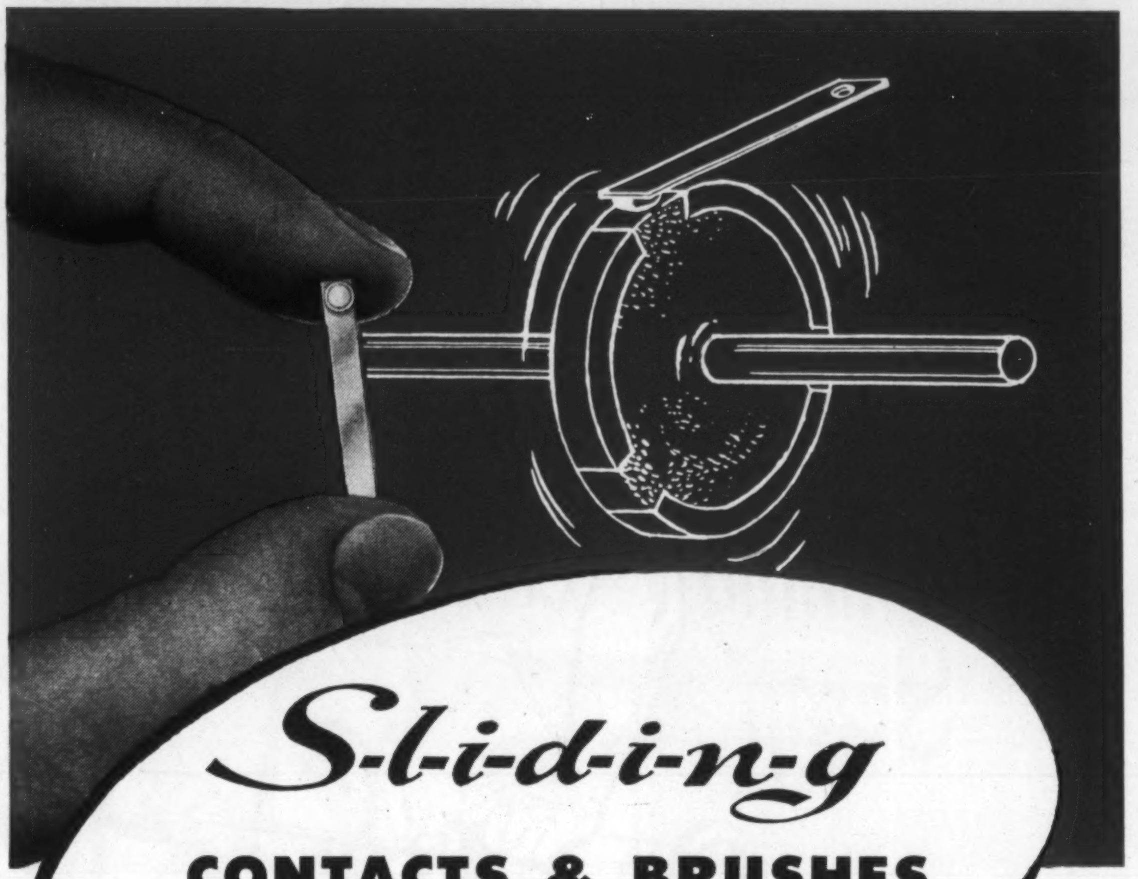
## Ferrophosphorus for Atomic Shielding

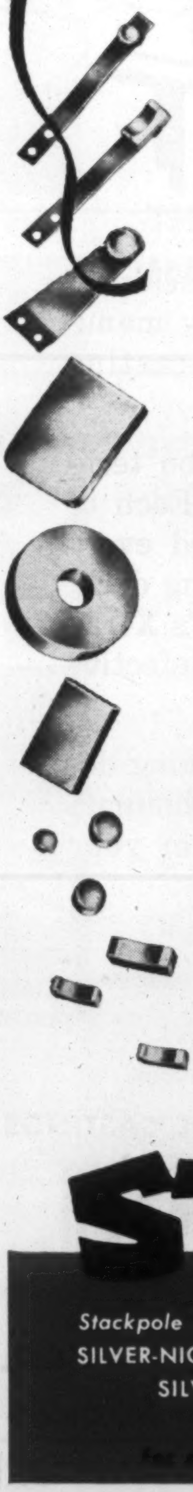
Ferrophosphorus is now being produced as an aggregate to be mixed with concrete to form a shielding material for atomic hot cells. Concrete - ferrophosphorus mixes obtain a density of 290 to 300 lb per cu ft, show good workability and no segregation during working, pouring or setting. The higher density of 300 lb per cu ft (in comparison with about 150 lb per cu ft for ordinary concrete) means that shielding walls can be thinner, simplifying remotely controlled work inside hot cell. Produced by *Victor Chemical Works*, 155 N. Wacker Dr., Chicago 6, ferrophosphorus is inert, therefore resulting concrete shields are insoluble in acids and will not develop corroded areas which could lead to "leakage" of radiation. The material can be mixed in standard concrete mixing equipment with ordinary cement.

## Metallized Ethyl Cellulose Sheet

Ethyl cellulose, a thermoplastic sheet material particularly well suited for vacuum forming, is now available in metallized form from *Coating Products*, Englewood, N.J. It has low moisture absorption and is useful over a wide temperature range. It is available in 24-in. wide rolls or cut-to-size sheet in thicknesses of 0.0075, 0.010, 0.015 and 0.020 in. The material is the latest addition to the company's line of Mirro-Brite metallized plastics.

*(More New Materials on p. 160)*





*S-l-i-d-i-n-g*

**CONTACTS & BRUSHES OF SILVER-GRAPHITE**

***. . . for minimum, more stable contact resistance . . . less radio noise interference . . . greater reliability***

From servo mechanisms to radar antenna operating units, calculating machines, midget motors and dozens of other exacting applications, sliding contacts or brushes of Stackpole silver-graphite assure maximum contact efficiency and life at minimum cost. Lowest radio noise levels short of using costly noble metals are obtained by using these silver-graphite units against a silver ring. For ordinary uses, a copper ring or commutator will suffice.

Available in sizes from 1/16" diameter upward, they can be supplied with silver-soldered backs for easy spot welding or brazing directly to supporting springs or arms and with or without shunts. Contacting assemblies are thus greatly simplified. Units are supplied either separate or mounted to specifications. They are made of silver with almost any desired percentage of graphite. Standard grades range from 0% to 50% graphite.

**STACKPOLE CARBON COMPANY**

***St. Marys, Pa.***

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*Stackpole contact material types include:* SILVER-GRAPHITE • SILVER-LEAD OXIDE SILVER-NICKEL • SILVER-MOLYBDENUM • SILVER-TUNGSTEN • COPPER-GRAPHITE SILVER-COPPER-GRAPHITE • GOLD-GRAPHITE • SILVER-IRON OXIDE and many special grades.

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You can't make money
Machining Scrap

Every casting that shows up defective during a machining operation costs you money. That's why so many manufacturers have Wellman fill their non-ferrous casting requirements.

Wellman's skilled craftsmen and modern inspection techniques insure a minimum of defective castings. Each of your castings is carefully supervised and checked every step of the way from the core-room to the shipping dock. Should you require 100% X-ray castings, Wellman's X-ray inspection facilities are available to eliminate defective castings completely.

Your profit is tied directly to efficiency, and machining defective castings is wastefully inefficient. Why not eliminate this problem at its source? Contact Wellman for your aluminum, bronze or magnesium casting needs.

Well-Cast MAGNESIUM, ALUMINUM AND BRONZE CASTINGS
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THE WELLMAN BRONZE & ALUMINUM CO.
Dept. 30, 12800 Shaker Boulevard Cleveland 20, Ohio

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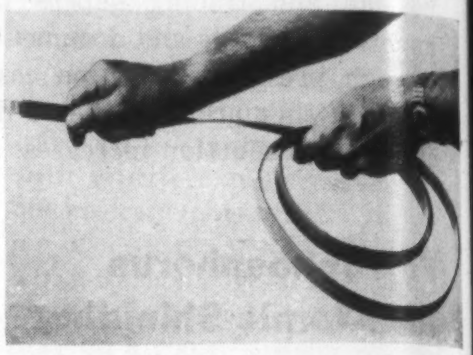
# New Materials, Parts, Finishes



## Plastics, Steel Tape

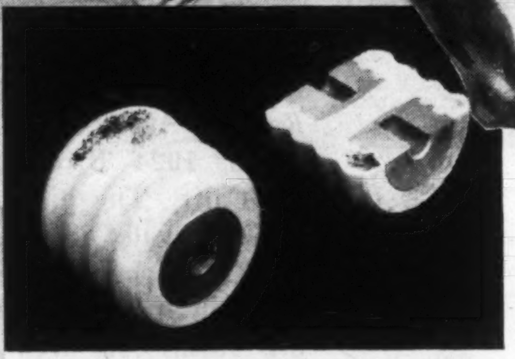
The strength of steel has been combined with the dielectric properties and abrasion and corrosion resistance of plastics in a new plastics-covered metal tape produced by *The Garrison Co.*, 218 Front St., So. Plainfield, N.J. Called Met-L-Tape, the material is basically a high tensile steel strap over which is extruded either vinyl, nylon or polyethylene. It can be fastened by bolts or rivets, or it can be spot welded by first stripping a section of plastics to expose the metal. Coatings are available in any color and can be heat-sealed at cut ends. Some of the uses for which the tape seems promising include: wire hangers for cable harnesses; bundling of wiring in large electrical installations; check straps for loom shuttles; and handles for portable radios or other equipment, where a strong, light strap is necessary.

## Leaded 52100 Round Steel Bars

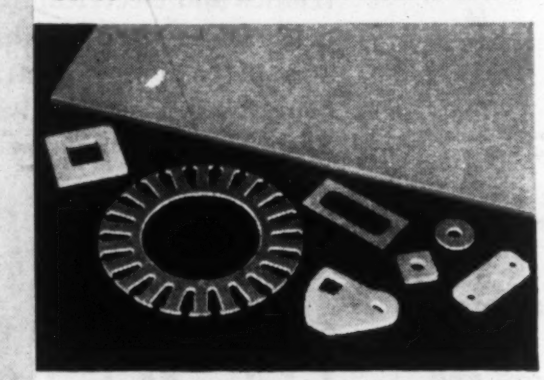
Leaded 52100 round steel bars are now available at the warehouse of, or by direct mail shipment from, *Peterson Steels, Inc.*, Union, N. J. The addition of minute particles of lead (0.15-0.35%) to standard SAE 52100 steel results in freer machining and faster cutting with no appreciable sacrifice in other properties of the alloy. Lead acts as a lubricant, reducing friction between tool face and chip, and resulting in a 0.25 to 40% improve-

# GLASTIC*

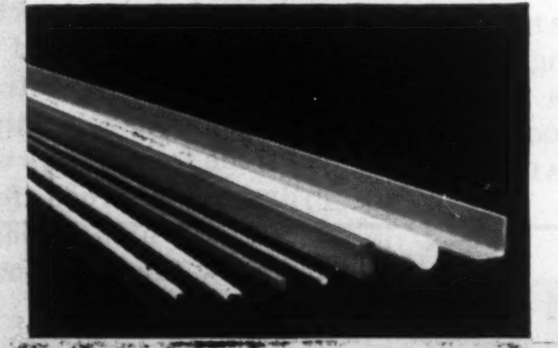
(GLASS REINFORCED PLASTIC)



GLASS REINFORCED PREMIX MOLDED PARTS



GLASS REINFORCED LAMINATE SHEET INSULATION



GLASS REINFORCED EXTRUDED STRUCTURAL SHAPES

## THE SYMBOL OF RELIABLE PROTECTIVE INSULATION IN THE ELECTRICAL INDUSTRY

For stability, heat resistance and ruggedness, Glastic* is becoming recognized as one of the finest insulating materials available. At lower cost, Glastic provides equipment manufacturers with increased performance ratings.

If your problem is obtaining or maintaining leadership, this new and accepted material can give you the competitive advantage you are looking for today. The Glastic Corporation offers a complete understanding of electrical design problems, combined with the "know-how" of glass reinforced plastics, to help solve your insulating problems.

Glastic is available in three forms . . . custom molded parts, laminated sheet, and extruded structural shapes . . . to meet your specific requirements. Glastic engineers stand ready to assist you in every phase of insulating problems. Please call on us . . . at no obligation, of course.

**SPECIFY GLASTIC FOR CLASS "B" INSULATION AT CLASS "A" PRICES**

ALKYD POLYESTER
GLASTIC
GLASS REINFORCED PLASTIC

For full information on how Glastic can help solve insulating problems, send for literature.

**THE GLASTIC CORPORATION**
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*An exclusive product of the Glastic Corporation

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For more information, turn to Reader Service Card, Circle No. 386

WANTED!

1001 "Vibration" Problems
for the lightweight and high YME
of Kentanium* **to solve**

Do you have a problem in structural engineering where the reciprocating motion of rigid elements can be improved by the lighter weight and greater resistance to deformation of Kentanium?

Perhaps it is a problem where the mass of a piston, a reciprocating block or a lever causes too much vibration in a machine if you run it as fast as you'd like.

Kentanium may be the answer.

Kentanium, a titanium carbide, weighs about two-thirds as much as steel and is 60% higher in Young's Modulus of Elasticity. It is a material with high resistance to wear, to oxidation and corrosion, to thermal shock, and retains high strength at temperatures where refractory alloys deform plastically.

Comparative Physical and Mechanical Properties

|  | YME million psi | Tensile Strength psi | d (lbs./cu. in.) | YME/d x 10⁶ | TS/d x 10³ |
|---|---|---|---|---|---|
| Magnesium alloy | 6.5 | 39,000 | .0645 | 101 | 600 |
| Aluminum alloy | 10.3 | 82,000 | .101 | 102 | 810 |
| Stainless Steel (304) | 26. | 185,000 | .286 | 90 | 64 |
| Titanium metal alloy | 16. | 150,000 | .163 | 98 | 920 |
| Kentanium (the titanium-carbide alloy) | 50. | 135,000 | .228 | 219 | 592 |

Typical Applications for Kentanium

Because of these unique properties, Kentanium is now in every engineer's mind for such applications as gas turbine blades, vane rings, impellers; diesel engine valve seats; hot rod mill guide inserts; bearings; bushings in contact with liquid metals; flame tubes; thermocouple protection tubes; anvils for spot welding; pressure sleeves; hot hardness tester balls. Kentanium can be supplied in tubes, rods, bars and highly complex shapes.

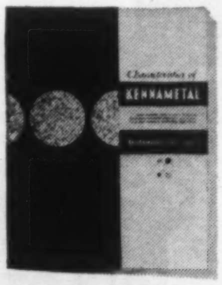
Kentanium may be the material you have been searching for to help you get your idea off the drawing board into production. Write to KENNAMETAL INC., Latrobe, Pa.

You should have this booklet

*Characteristics of Kennametal** Booklet No. B-111 gives the physical, mechanical and corrosive properties of Kentanium and Kennametal, data on the various grades and applications of these versatile engineering materials. Send for your copy today.

*Registered Trademarks

7271



INDUSTRY AND
KENNAMETAL
...Partners in Progress

For more information, turn to Reader Service Card, Circle No. 310

## New Materials, Parts, Finishes

ment in machinability, lengthening tool life and producing better as-machined finishes. Addition of lead does not appreciably affect hardenability, tensile strength, ductility and impact strength of the alloy, and it is heat treated in the same way as unleaded 52100.

### High Purity Aluminum Pig and Foil

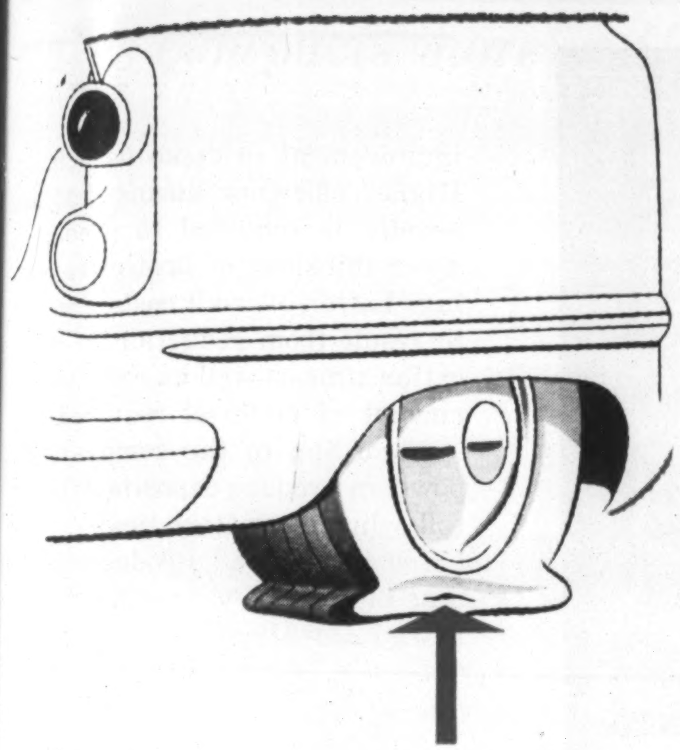
Aluminum pig, which contains 99.99% aluminum, is being produced in commercial quantities by *Kaiser Aluminum & Chemical Corp.*, 1924 Broadway, Oakland 12, Calif. The high purity metal is being rolled into foil of 99.97% purity for the electronics industry and will also be made available in pig form. As well as the electronics and electrical industry, the material is used in the chemical and petroleum industries in the manufacture of catalysts and is in demand for jewelry and other decorative uses.

### New Metal-Joining Materials

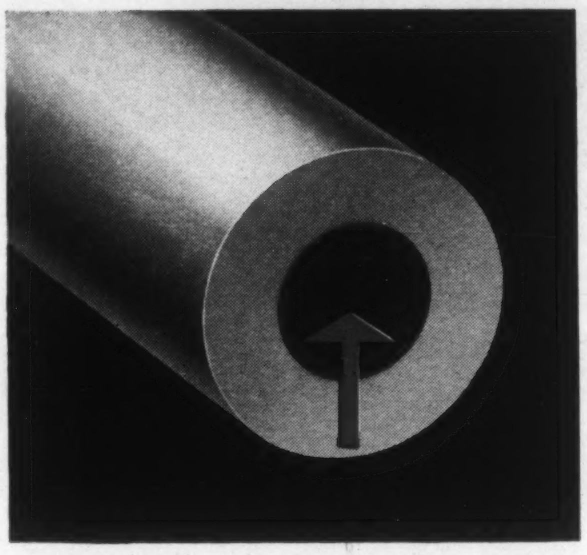
Several new products have recently been announced for joining metals. They are: three hard facing materials; a high carbon electrode for build-up work; a low hydrogen electrode for welding armor and high strength steels; and a low fuming bronze rod with a flux coating.

**Hard facing powder**

A new series of Colmonoy alloy powders, said to improve deposit efficiency when used in Spraywelded hard facing applications, is being marketed by *Wall Colmonoy Corp.*, 19345 John R. St., Detroit 3. The new powders are of nickel-chromium-boron alloys, Colmonoy Nos. 4, 5 and 6, and are said to provide as much as 10%



a hole here is a letdown . . .



a hole here is a lift

***Crucible Hollow Tool Steel Bars*** can step up output on most any production line where ring shaped or hollow parts are made. Why? Simply because the hole is already there. There's no need for drilling, boring, or hole-sawing. And that's where you save production time, increase machine capacity, and avoid scrap losses!

Crucible's famous tool steel grades are available to you in hollow form, in almost any combination of OD, ID and length. In fact, your local Crucible warehouse can give you immediate delivery of these popular grades — KETOS oil-hardening, SANDERSON water-hardening, AIRDI 150 air-hardening, and NU DIE V hot-work tool steels.

Ask your local Crucible representative how you can save time and money by using Crucible Hollow Tool Steel Bars. Call him today, at our nearby Branch Office. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

**Visit us at Booths 830-832 Production Engineering Show, September 6-16, Navy Pier, Chicago.**

**CRUCIBLE** **first name in special purpose steels**

**Crucible Steel Company of America**

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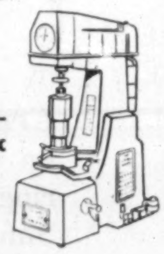
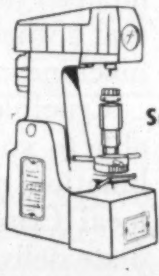
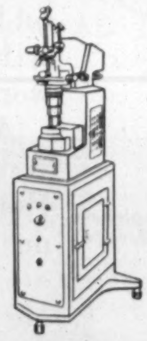
Fully Automatic





Tukon Micro and Macro Hardness Testers

ACCO products

Wilson "Rockwell"* Hardness Testers

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## New Materials, Parts, Finishes

improvement in deposit efficiency. Higher efficiency means that less powder is required to produce a given thickness of protective coating. Lower over-all costs are said to result from reduction in application time as well as reduction in amount of material required.

According to the company, the powders produce deposits with the following characteristics:

*Colmonoy No. 4*—Produces hardness of Rc 35-40. Specific gravity is 8.22; melting point is 2025 F.
*Colmonoy No. 5*—Produces hardness of Rc 45-50. Specific gravity is 8.14; melting point is 1950 F.
*Colmonoy No. 6*—Produces hardness of Rc 56-61. Specific gravity is 7.8; melting point is 1900 F.

All the deposits are said to have high corrosion resistance, red hardness, weldability and abrasion, impact and gal resistance.

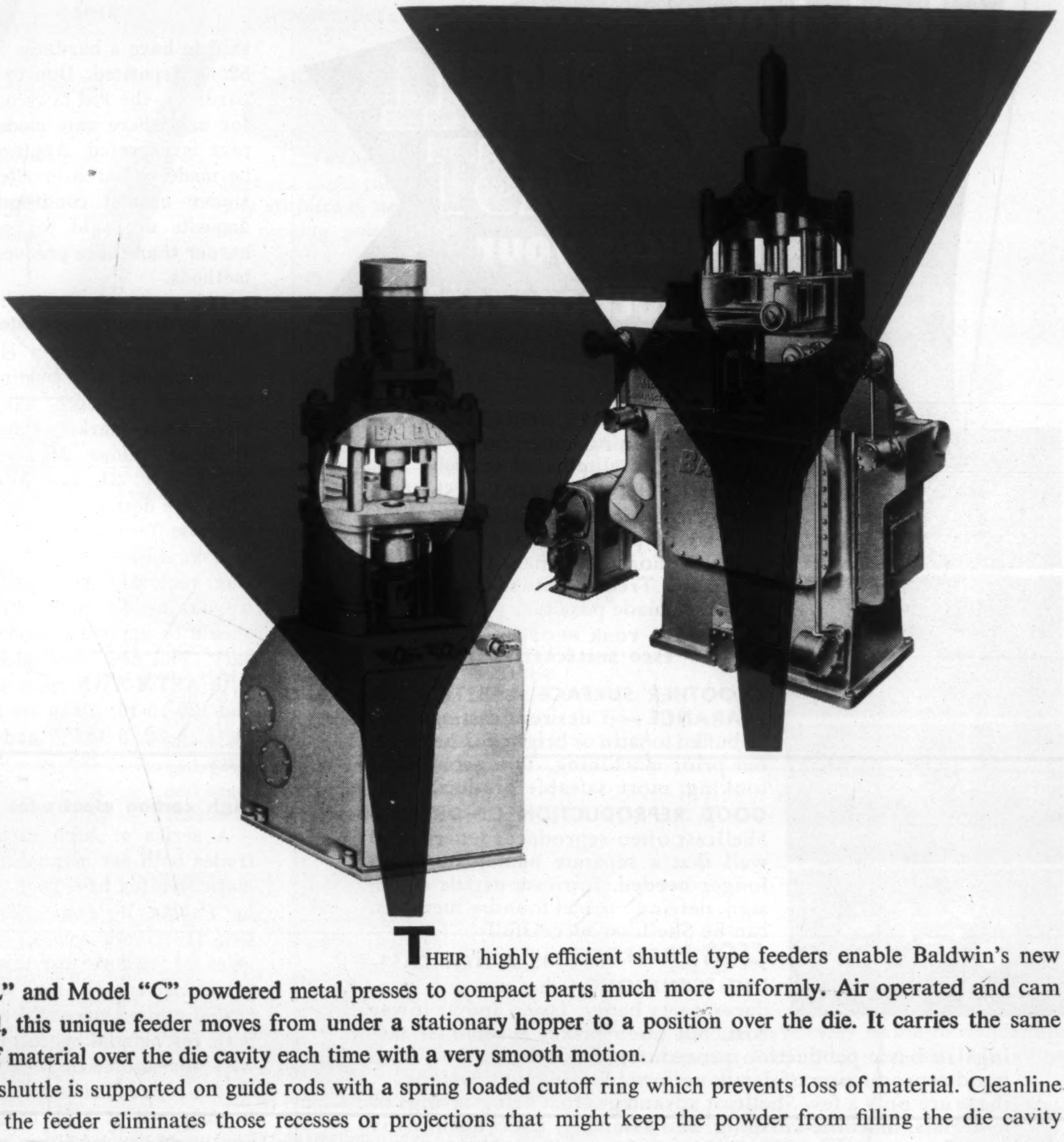
### Fast hard facing rod

A high speed electrode for hard facing heavy duty equipment has been developed by *Mir-O-Col Alloy Co., Inc.*, 312 North Ave. 21, Los Angeles 31. It is designed to deposit, in the same amount of time, 1/3 more metal than conventional type rods. Designated 4T-S, it is a medium alloy, ductile rod, the deposit from which will not chip or spall from base metal. It is especially recommended for use on tractor track rails and grousers.

Mir-O-Col Alloy has also marketed a hard facing rod designed for use where corrosion and abrasion at elevated temperatures are encountered. Designated No. 11, the electrode is said to retain almost all of its characteristics at red heat and to produce a smooth, bright, non-oxidized deposit, free from porosity. It is said to flow readily on clean base metal, providing minimum penetration. It is particularly suited for use on valves, tongs, chemical equipment and food machinery equipment.

It is a nonferrous alloy, containing cobalt, chromium and tungsten. Resulting deposits are

# PRECISE FILLING OF DIES *by new Baldwin powdered metal presses makes compacts more uniform . . .*



THEIR highly efficient shuttle type feeders enable Baldwin's new Model **"L"** and Model **"C"** powdered metal presses to compact parts much more uniformly. Air operated and cam controlled, this unique feeder moves from under a stationary hopper to a position over the die. It carries the same volume of material over the die cavity each time with a very smooth motion.

This shuttle is supported on guide rods with a spring loaded cutoff ring which prevents loss of material. Cleanline design of the feeder eliminates those recesses or projections that might keep the powder from filling the die cavity completely.

This is just one of the ways you'll benefit by specifying Baldwin Model "L" (50-ton) or Model "C" (100-ton) presses to meet the growing demand for powdered metal parts. These new presses are the very first designed specifically for use in compacting metal powders. Both feature sealed mechanisms, hydraulic heads, special fill adjustments, automatic lubrication and variable cycling.

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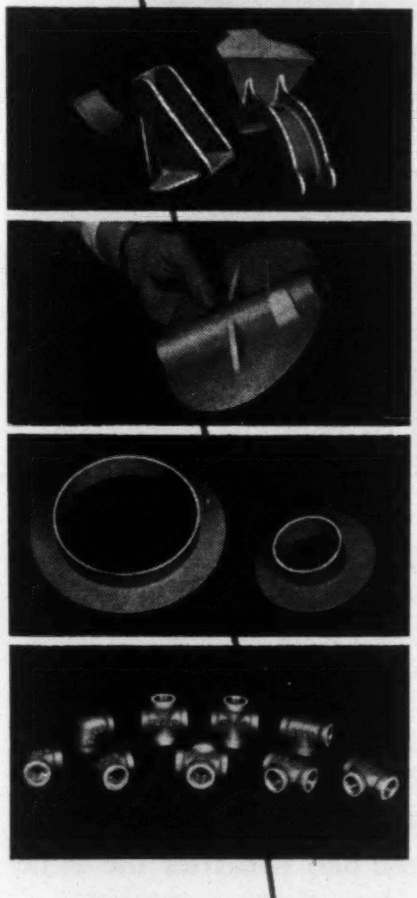

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For more information, turn to Reader Service Card, Circle No. 507

## New Materials, Parts, Finishes

said to have a hardness of Rc 50-52 as deposited. Due to its high hardness, the rod is recommended for use where only moderate impact is expected. Application can be made by torch or electric arc. Under normal conditions, torch deposits are said to be slightly harder than those produced by arc methods.

### Low hydrogen electrodes

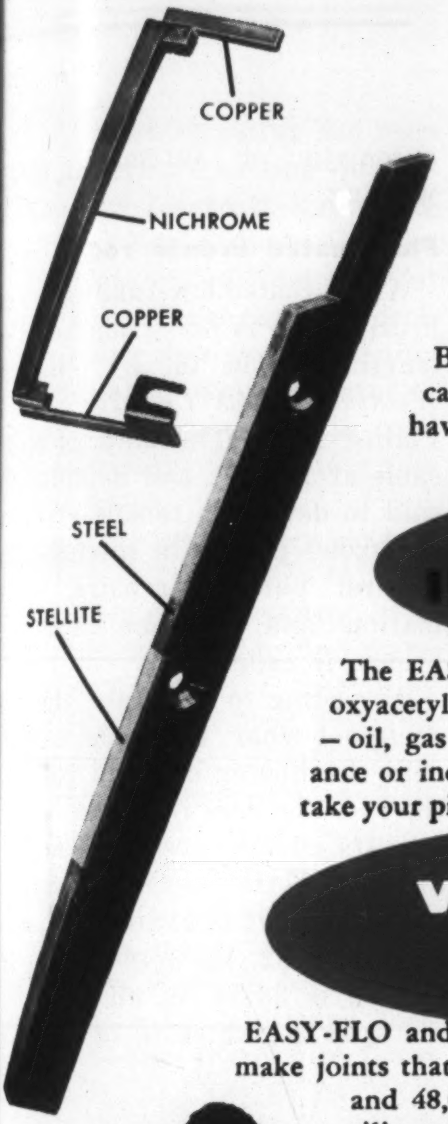
New low hydrogen electrodes, recommended for welding armor and high strength alloy steels, have been marketed by *Pacific Welding Alloys Mfg. Co.*, 310 North Ave. 21, Los Angeles 31. They are designed for all-position welding. They are said to provide smooth bead contour and easy slag removal. Application is by a.c.-d.c. or d.c. only. Preheating should be applied wherever necessary. The new electrodes comply with ASTM-AWS specs 100-15-16 and 120-15-16. They are available in 1/8, 5/32, 3/16, 1/4 and 5/16 in. sizes.

### High carbon electrodes

A series of high carbon electrodes both for manual and automatic welding have been marketed by *Pacific Welding Alloys Mfg. Co.*, 310 North Ave. 21, Los Angeles 31. There are three types of electrodes in the series: a coated and an uncoated electrode, both for manual operation, and a wire for automatic welding. The coated rod, called Brown Coating, is composed of high carbon wire and is said to lay down a deposit with 0.60-0.70% carbon. It is said to be suited for any type of manual build-up work. Application is by either a.c. or d.c. straight polarity. The other high carbon electrode for manual application has no coating. It can be used for either electric or acetylene build-up work. Carbon content is said to be approximately 0.60-0.70%. The automatic wire can be applied with either submerged or open arc. It can also be used for semi-

# The amazing VERSATILITY of EASY-FLO and SIL-FOS

You'd have to go a long way to find a brazing job that these low-temperature silver brazing alloys can't do.

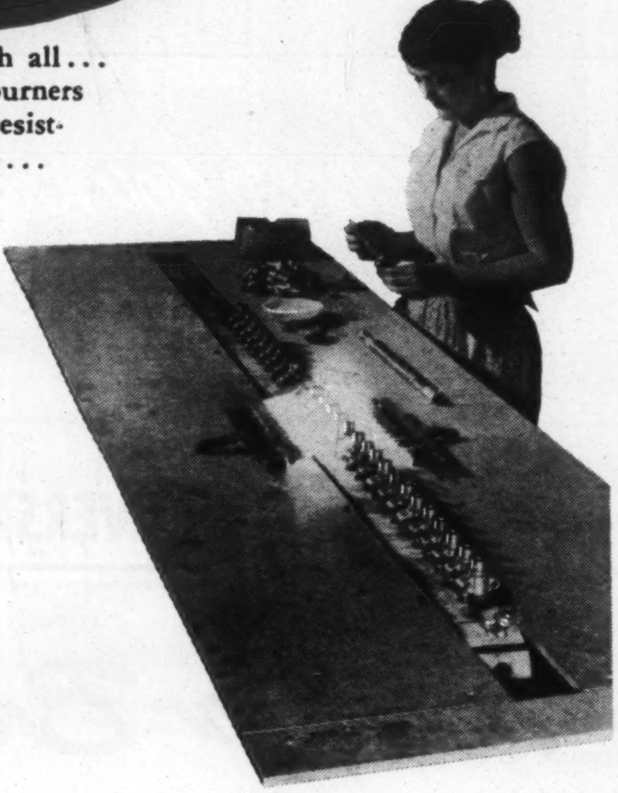


## VERSATILITY IN METALS

Between them, the EASY-FLO and SIL-FOS alloys will join practically all ferrous, non-ferrous and dissimilar metals and alloys that have melting points above the alloys' respective flow points.

## VERSATILITY IN HEATING METHODS

The EASY-FLO and SIL-FOS alloys work well with all... oxyacetylene, natural and city gas torches – gas-air burners – oil, gas and electric furnaces – electric induction, resistance or incandescent carbon – molten alloy or salt dip... take your pick.



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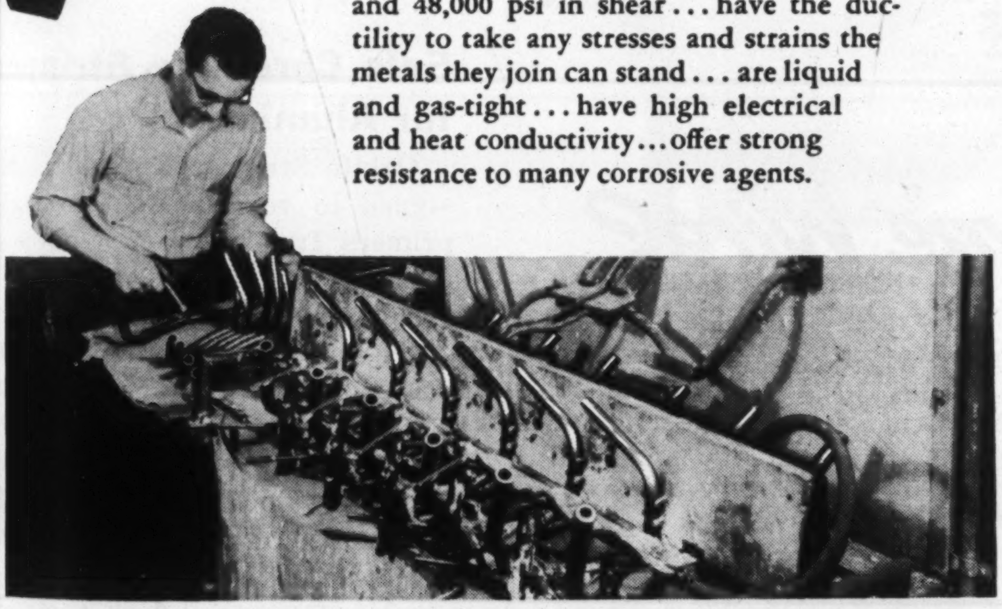
EASY-FLO and SIL-FOS naturally and consistently make joints that... go up to 130,000 psi in tension and 48,000 psi in shear... have the ductility to take any stresses and strains the metals they join can stand... are liquid and gas-tight... have high electrical and heat conductivity... offer strong resistance to many corrosive agents.



In the job shown here induction heating is used to braze steel handle bars to stems with EASY-FLO 35 — 6 at a time in 32 secs. The two jobs shown at left above are gas torch brazed with EASY-FLO 45. Job at right shows brass gasoline petcocks being brazed with EASY-FLO 45 by propane-oxygen burners — 1200 per hour.

**ADD** to their 3-ply versatility the fact that their low flow points protect metals and save gobs of time, labor and heat — and you have every reason to standardize on the EASY-FLO and SIL-FOS alloys for all your brazing.

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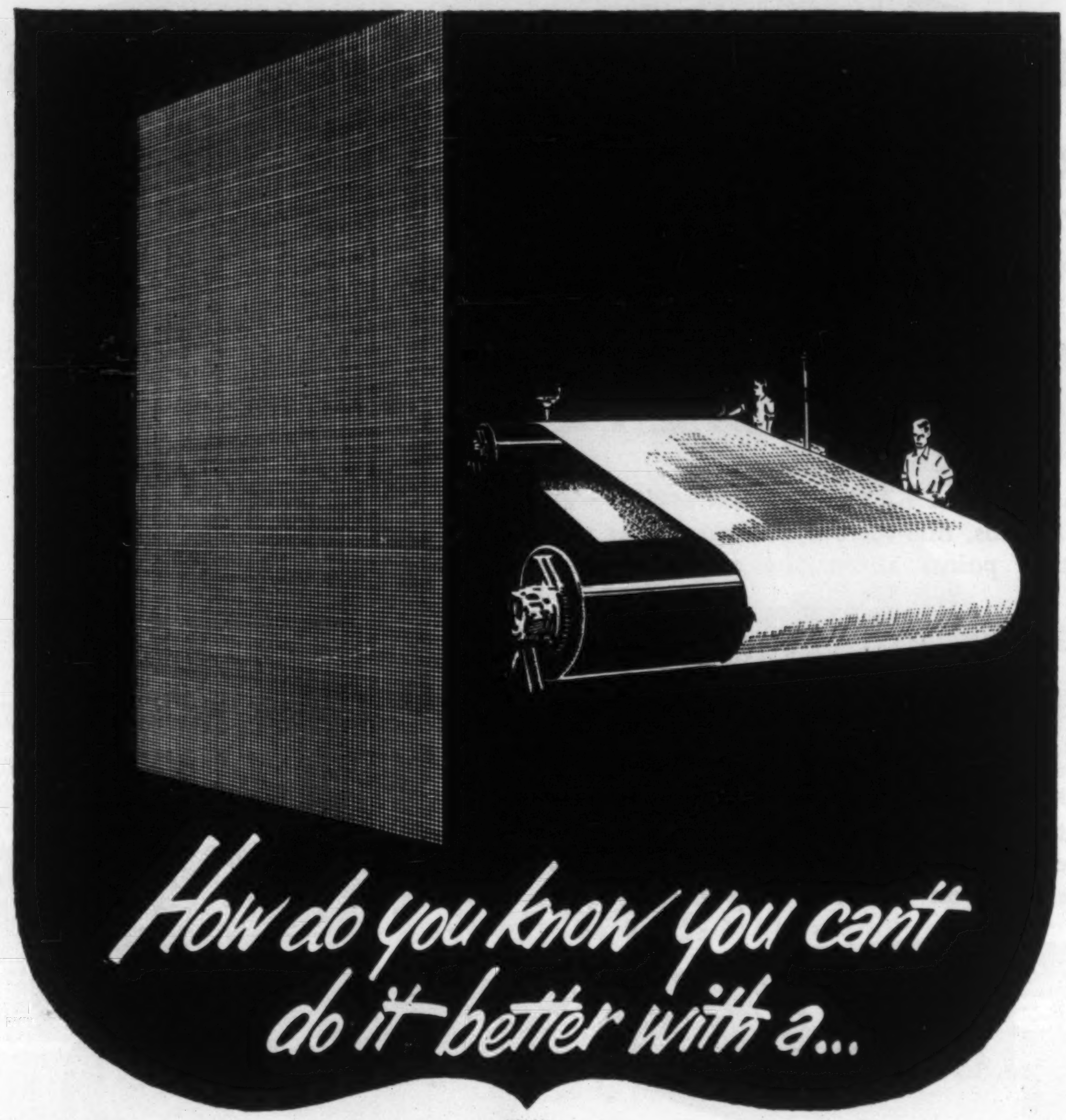
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# New Materials, Parts, Finishes

automatic or automatic squir welding.

### Flux-coated bronze rod

A flux-coated low-fuming bronze brazing rod is being marketed in lengths of 36 in. by *All-State Welding Alloys Co., Inc.*, White Plains, N. Y. The alloy is applicable at 1650 F, and deposits are said to develop a tensile strength of 60,000 psi. It is intended for general purpose repairs, reclamation and assembly wherever bronze is called for.

According to All-State, the flux does not char or leave carbon, does not blister or burn back up the rod, nor does it attract moisture. Its effectiveness does not deteriorate with repeated wetting and drying. It is available in core sizes of 3/32, 1/8, 3/16 and 1/4 in. Length is 36 in. in all sizes but the 3/32 in., which is 18 in. long.

## Safe Chromate Stripper for Aluminum

Oakite Stripper No. 110 is designed to remove zinc chromate primers from aluminum without affecting the metal surface. Developed by *Oakite Products, Inc.*, 132H Rector St., New York 6, the material is a two-phase solvent which should be used full strength. Parts to be stripped are immersed completely in the solvent under the surface oil seal, which should be maintained continuously. Stripper No. 110 has a flash point of 290 F and works faster when heated to 140 to 180 F. A pressure water rinse, warm or cold, is recommended to float off loosened zinc chromate material.

## New Lead-Bearing Steel Plate

Improved machinability, better welding, polishing and plating properties are claimed for a new leaded steel plate, as compared

For more information, Circle No. 516 ➤

with one to which sulfur had been added to improve cutting quality. Marketed by *Joseph T. Ryerson & Sons, Inc.*, Box 8000-A, Chicago 80, the plate called New E-Z-Cut is said to have flame cutting, forming, grinding and case hardening characteristics equal to those of the free machining plate the company previously sold under the E-Z-Cut name.

Because of its superior welding properties, in comparison to those of the high sulfur content steel plate, it is expected to find many uses where extensive machining and welding are involved. Initially, the plate will be available from stock in thicknesses of ¼ to 3 in.

The present theory of lead addition is that lead acts as a lubricant to the cutting tool. There is less friction, requiring less cutting power; there is better chip formation, with minimum tool-edge build-up; there are fewer tool grinds; and the as-machined finish is improved. Use of lead-bearing steels has resulted in output increases up to 50%, and tool life increases up to 300%.

## Four New Adhesives

Four new adhesives have recently been marketed by three companies. They are designed for bonding pliofilm to foils, bonding plastisols to metals, bonding labels to plastics, and joining leather.

### Bonds foil

A new solution adhesive for bonding pliofilm to aluminum foil has been announced by *American Resinous Chemicals Corp.*, Peabody, Mass., and *Reslac Chemicals Inc.*, 3634 W. 38th St., Chicago 32. Though specifically developed for bonding foil to pliofilm, the adhesive, called Reslac 2334-501, is said to be suitable for joining a variety of films and foils such as Mylar, Saran, polyethylene and cellophane. It may be applied by gravure press or

For more information, Circle No. 306 ➤

Spincraft did it for Gulf Oil...

*Spincraft can do it for you!*

"Marsh Buggy" travels over rugged terrain on spun aluminum wheels

another example of spinning and fabrication by Spincraft

13 DIFFERENT OPERATIONS

The "Marsh Buggy" rolls on sturdy, lightweight aluminum wheels — spun and fabricated by Spincraft. Even if all four balloon tires fail, the spun aluminum air-tight wheel drums will keep the vehicle afloat. Wheel flange segments, extensions, .118" thick 52SO aluminum stiffener ribs, No. 11 U. S. gauge (.125" thick) stainless steel front hub cones were machined and assembled to complete the wheels. In addition to spinning, Spincraft performed the following operations: welding, grinding, polishing, machining, punching, braking, drilling, tapping, sawing, riveting, assembly and testing.

When Gulf Research & Development Co., a division of Gulf Oil Corp., contracted to build their world-famous "Marsh Buggy" for the U. S. Army, Gulf called on Spincraft to fabricate all four wheel assemblies.

These huge wheels are designed to bear loads of 1,500 to 4,000 lbs. Combining strength with lightweight, these tough aluminum alloy wheels can take grueling cross-country punishment. The 10-ft. dia. tires easily negotiate swamp, water, sand, deep mire and other difficult terrain, at speeds from ¼ to 40 miles per hour.

This is another example of Spincraft's versatility and manufacturing skill. Complete facilities are available for all types of contract manufacture — finished parts, assemblies and complete products. Take advantage of our modern tools for spinning and fabricating. They can pay off in savings for you, too.

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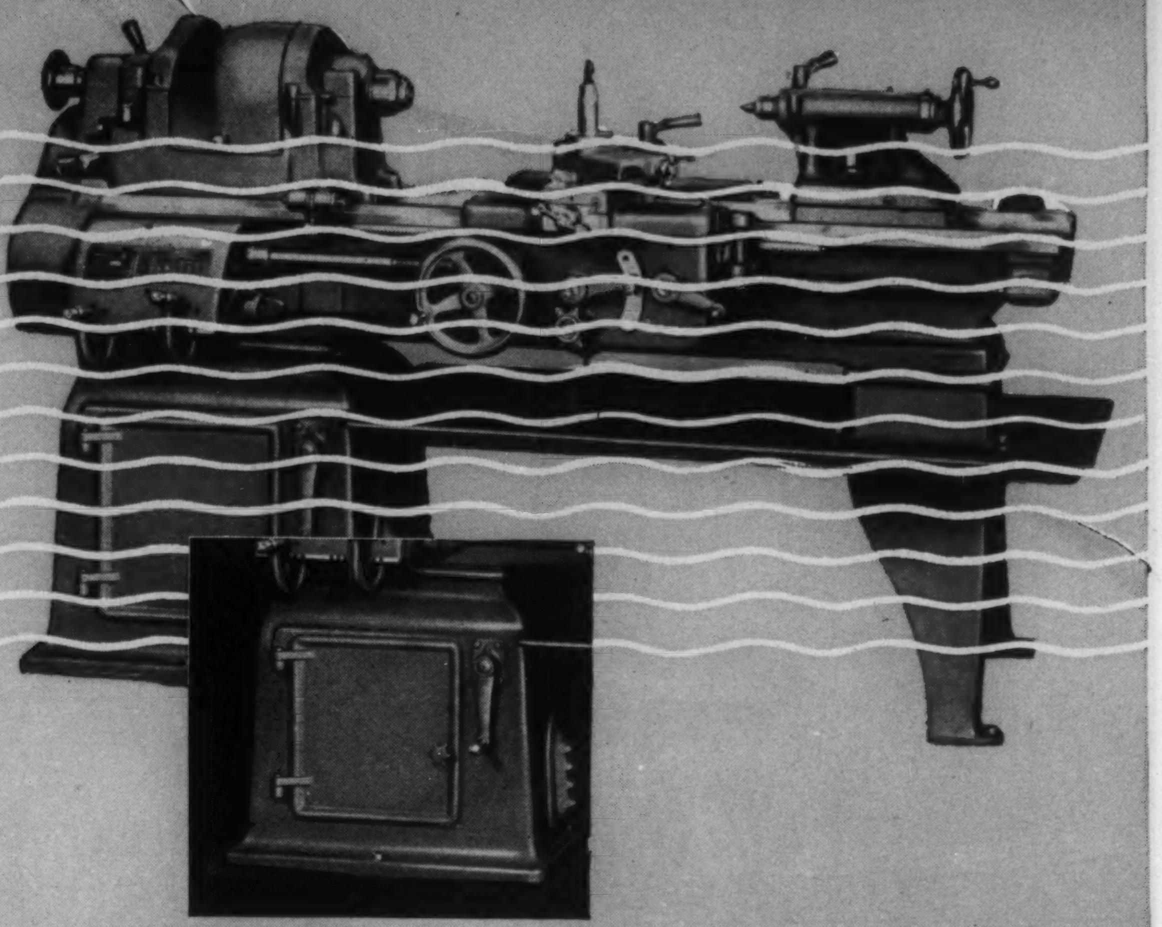

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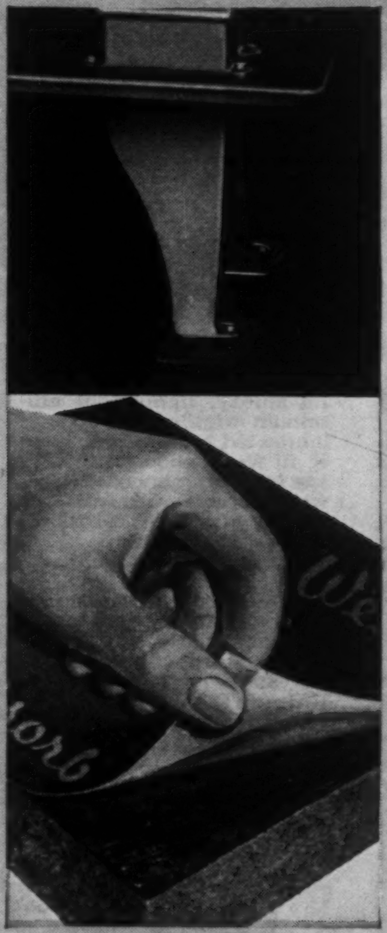

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# New Materials, Parts, Finishes

roll coater, and oven-dried to re-move the solvent. Bonding at 175 F can be carried out on standard laminating equipment. The bond is said to be heat and water resistant and flexible at low temperatures. The material is available in colors if required.

**Plastisol-metal adhesive**

A new adhesive for bonding plastisol materials to metallic surfaces has been developed by *Watson-Standard Co.,* 217 Galveston Ave., Pittsburgh 12. Designated No. 12-837, the adhesive provides a bond that is said to be resistant to chemicals and will prevent subsurface corrosion under the plastisol film. It must be cured at 380 to 400 F for 10 min to obtain optimum adhesion. When properly applied, it will provide adhesion of 18 to 24 lb per linear in. Metallic surfaces must be free from oil, grease and dirt.

**Labels-to-plastics**

Kleen-Grip, a new type adhesive, has been marketed for joining labels to plastics. Developed by *Adhesive Products Corp.,* 1660 Boone Ave., New York 60, it can be used to stick labels to polyethylene, polystyrene acetate and other plastics. According to the company, the adhesive will hold labels on the plastics indefinitely, yet it can be easily removed by peeling off the label, stripping the adhesive at the same time. Kleen-Grip can be applied by brush or by labeling machines.

Adhesive Products Corp. has also developed a double strength adhesive, Griptex, for use in manufacturing stitchless belts. In the past, deterioration of bonds has been caused by the action of natural oils in the leather. According to the company, strength of bonds obtained with the new material increases with age. It can be applied by spray or cementing machine as well as by brush.

*(More New Materials on p. 174)*

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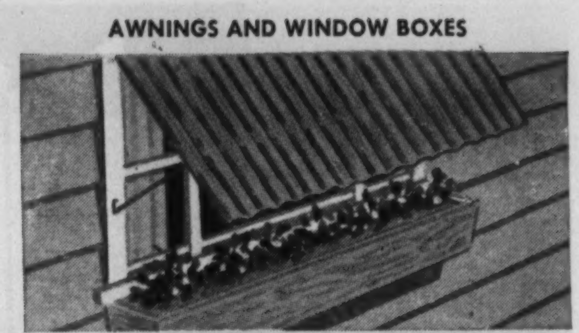
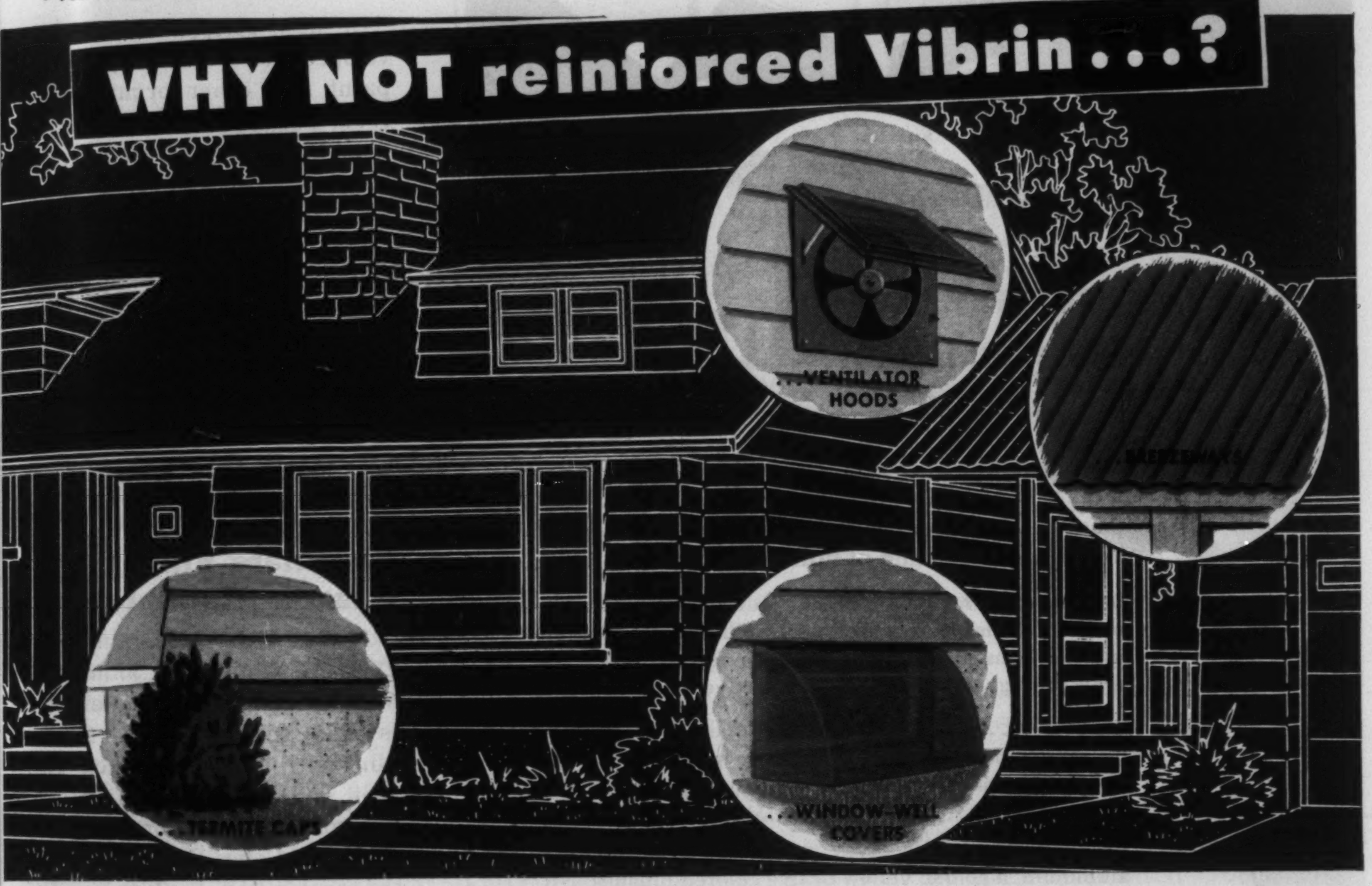
AWNINGS AND WINDOW BOXES





Lightweight breezeway roofs of reinforced Vibrin® can't rust, rot, or corrode. These colorful translucent panels can be made in various degrees of light transmission; for appearance sake, all panels can reflect the same degree of color.

Reinforced Vibrin termite caps will outlast the house. Easily fabricated and attached, they are not affected by moisture or the chemicals in soils and masonry. They will not harbor or support maggot or insect life. And on top of all this, reinforced Vibrin is an excellent electrical and thermal insulator.

Ventilator hoods of Vibrin will deaden sound...are not affected by oils and greases...can't absorb any cooking odors. Because they are rust- and corrosion-proof, run-off water cannot stain or discolor the siding. The color is built in. No painting is necessary.

Translucent window-well covers will allow plenty of light into the cellar. And they never need painting—playful children, sharp garden tools, and errant lawnmowers cannot scratch, scuff or even dent Vibrin.

These are just a few of the many home applications of reinforced Vibrin. So why not consider Vibrin for greenhouses, patio dividers, doors, and garden houses—wherever economy, light weight, beauty, and practicality are called for?

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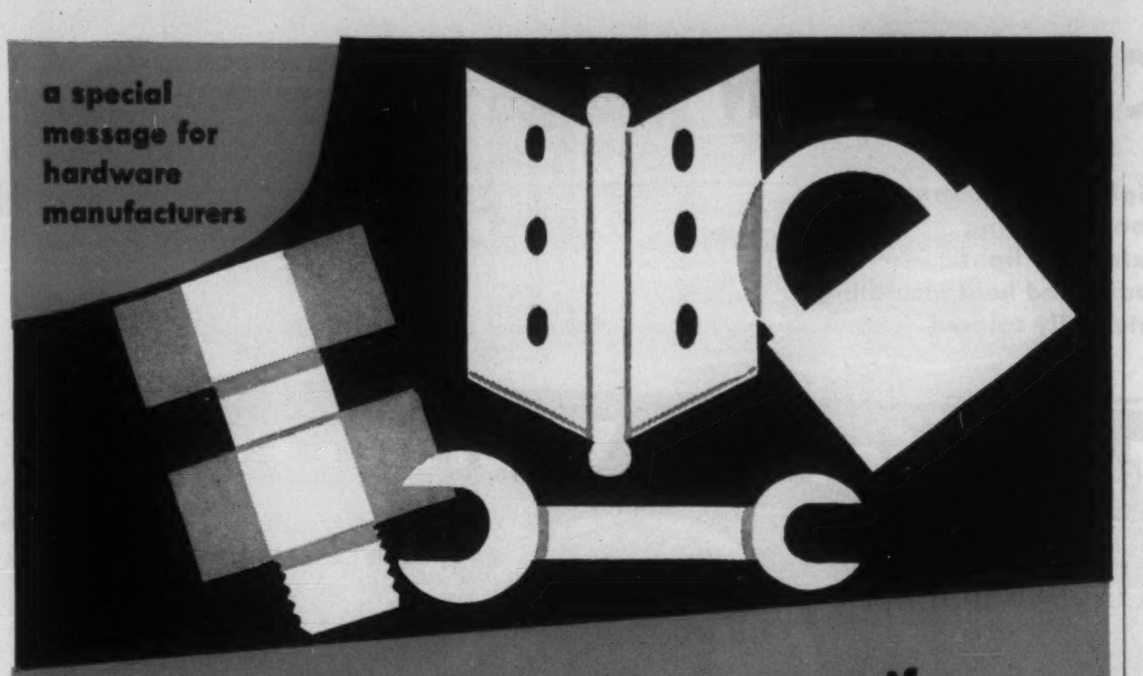

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# New Materials, Parts, Finishes

## Paint Stripper Cleans Plastics

A new stripper has been developed for chemically removing paint and other organic finishes from plastics safely and without damaging the plastics base. Called Liquid Stripper #11, the material has been developed by *Northwest Chemical Co.*, 9310 Roselawn Ave., Detroit 4. It involves no fire hazard, no odor, no fumes and is nontoxic. It converts paint films into soluble form so that they may be easily rinsed off. The stripper contains only chemicals that can be flushed through usual waste disposal systems.

## Chromate Film Guards Aluminum

Luster-On Aluminum Sealer 222-M is applied to aluminum in one dip at room temperature and is said to produce a chromate film with good corrosion resistance and which serves as a base for paint. Developed by *The Chemical Corp.*, Springfield, Mass., the sealer can replace anodizing where hardness is not a prime factor, according to the company. It resists salt spray attack for 600 hr. It meets specification MIL-C-5541, is said to adhere well, does not leach easily, and can be dyed in many pastel colors.

now even better
invest more in
Defense Bonds

# Contents Noted

*A digest of papers, articles, reports and books of current interest to those in the materials field.*

**This Month:**
- *Tougher cermets*
- *Uses for chromized metals*
- *Low thermal expansion alloy*
- *Deterioration of auto finishes*
- *Arc-welding aluminum to steel*

## Infiltration Provides Cermets With Higher Impact Strength

Though metal-bonded titanium carbide is one of the most promising of the cermet materials for use at temperatures above 1600 F, it still possesses the brittleness common to all cermet materials. Recent work on producing titanium carbide-base materials by the infiltration technique shows promise of overcoming this drawback by providing materials with greatly improved impact strength.

According to a paper by L. P. Skolnick and C. G. Goetzel of Sintercast Corp., at 1800 F at a stress of 15,000 psi, the life of some of the infiltrated titanium-carbide grades is over 1000 times that of cast X-40. The accompanying table compares micro-charpy impact values for the materials as compared with those of X-40 and some conventionally produced titanium-carbide base cermets. Though the impact values are admittedly still far below those for X-40, they do show a substantial increase over those of conventionally produced cermets, and offer promise of even greater improvements in the future.

### Infiltration results

In infiltration, a skeleton body of titanium carbide is prepared by pressing carbide powder at low pressures, sintering to form a coherent mass and then filling the voids of the skeleton body with a high-strength material generally of the superalloy type. Since impact failures initiate in the carbide phase, improvements in impact strength are attained by producing a material of fine-grained spheroidal carbide structure with the carbide isolated in the metal matrix. Superior impact values can be expected once reliable methods for controlling titanium-carbide grain shape, growth and distribution are developed.

Stress-rupture properties of the materials do not seem to be as structure-sensitive as impact strength. Concentration of titanium-carbide does, however, affect stress-rupture life. To obtain increased strength, percentage of carbide in the body can be increased within moderate limits, though extremely high carbide concentrations tend to decrease other properties such as impact strength and ductility. To obtain high strength without sacrificing such properties, special matrix metals are being developed.

Several successful engine tests have been carried out. In one test, infiltrated titanium carbide withstood 100 hr under accelerated and aggravated operating conditions as the stator guide vane in a J-35 engine. Conventional cemented titanium carbide usually fails rapidly under similar conditions. In another series of tests, supercharger buckets of infiltrated titanium carbide have lasted 300 hr without failure.

### Process analysis

The low initial compacting pressures used in the infiltration technique are said to allow high complexity of shape and reduction of die wear. The process does require two heating operations, but the conventional sintering technique generally makes use of a presintering operation to permit ready forming before final high

**IMPACT STRENGTH OF TiC CERMETS AND CAST X-40**[1]

| Material | 70 F | 1600 F | 1800 F |
|---|---|---|---|
| X-40 | 40–50 | 50+ | 50+ |
| X-40, aged | 30–40 | 50+ | 50+ |
| Ni-cemented Ti (CbTa)C | 4.1– 5.1 | 5.2– 6.2 | 7.9– 8.5 |
| Ni-Mo cemented Ti (CbTa)C | 1.5– 2.8 | 2.2– 3.2 | 2.5– 3.0 |
| Ni-cemented Ti (Cr)C | 1.8– 3.0 | 5.0– 5.3 | 5.3– 6.0 |
| Infiltrated TiC (No. TC-66-I) | 5.6– 8.3 | 8.5–12.0 | 8.6–10.5 |
| Infiltrated TiC (No. SCA-100) | 10.5–14.5 | 12–19.5 | 17.5–23.5 |

[1] *Results, in in.-lb., of Micro-Charpy impact tests on 3/16-in. square by 1-½-in. unnotched specimens.*

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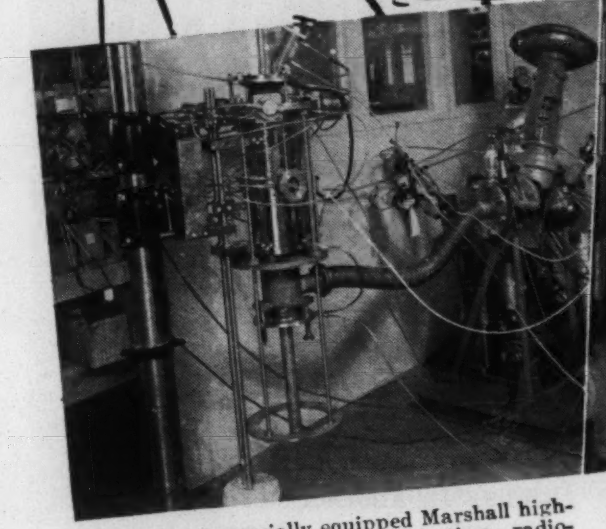
**Borides?**
**Carbides?**
**Nitrides?**
**Silicides?**



Above.—A specially equipped Marshall high-temperature furnace for testing radioactive materials.

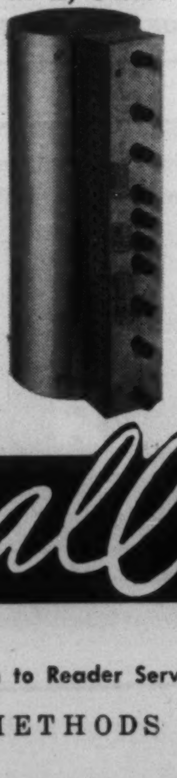
Marshall Tubular Furnace shown in tensile-test service above. Furnaces are also built for creep-test, stress-rupture

"Man loves to wonder", said Ralph Waldo Emerson, "and that is the seed of his science".

Perhaps you too are one who wonders . . . maybe you're wondering what metal compound would be best for your jet engine rotors or gas turbine rotors, or metal for some other service where high temperatures and stresses are extreme.

If so, Marshall Tubular Furnaces will aid you in the search. These Furnaces give you creep rates, tensile strengths and stress-rupture data, accurately and efficiently, for metals under test. The Furnaces are sturdy, adaptable units. If necessary they can be altered to suit your special conditions. Let us aid in solving your test furnace problem. Marshall Products Co., 270 W. Lane Ave., Columbus 2, Ohio.

In Marshall Furnaces maintenance of desired temperature — always paramount — is assured by ingenious design. Temperatures in this furnace can be uniform, spot-regulated or controlled zone-by-zone.



The Marshall Control Panel is an important adjunct of the Marshall Furnace. Control circuit of this Panel regulates heat and holds temperature fluctuation in the furnace to a minimum. Write for literature.

Marshall

FURNACES--
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temperature sintering.

Sintered bodies can be infiltrated by a variety of techniques, depending on the type and density of the skeleton and the infiltrant alloy composition. In many aspects infiltration technique is similar to investment casting. Close tolerances can be held by infiltrating in a refractory mold similar to an investment casting mold, by coating the skeleton body with a suitable refractory. Infiltration is primarily based on capillary forces, but gravity or external force may be added. Direction of pentration of the liquid metal may be longitudinal or transverse, downward or upward. Distances as great as 10 in. with cross-sections as narrow as ¼-in. square have been successfully infiltrated obtaining uniform properties.

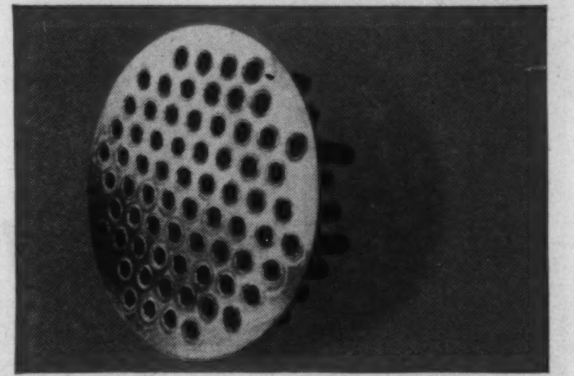
The authors point out that versatility of the process offers promise for future applications. Most alloys capable of being produced in the massive state can be used as infiltrants. Nickel, cobalt, and both austenitic and ferritic iron-base alloys have been used. The process further permits development of components wherein pure metal is completely bonded metallurgically with the infiltrated titanium carbide. This would permit production of a turbine bucket with an integral metallic root section. Such a root section would be readily machinable into the conventional fir tree configuration, it would provide increased toughness in the connecting region, and it would possess advantages of fitting, welding and a sufficiently lower thermal conductivity so that engaging portions of the wheel would remain at a tolerable temperature.

## What Chromized Metals Can Do

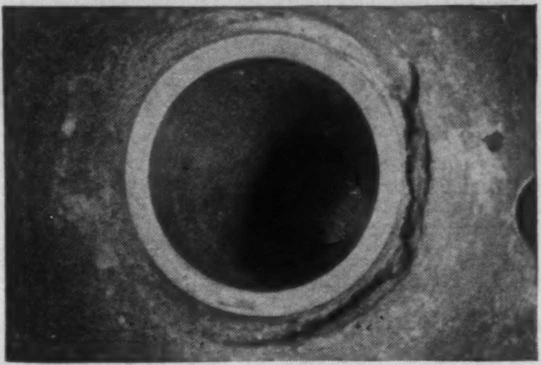
Chromizing, a method of diffusing a layer of chromium into the surface of a metal, has been used for some time to impart corrosion, heat or wear resistance to

# TITANIUM

## SOLVES TOUGH CORROSION PROBLEMS



**HOT NITRIC ACID** at pressures of 300 psi took a high toll of stainless-steel condenser tubes at a Du Pont plant—until this titanium "top-hat" was installed. Fabricated entirely of titanium, it provides a protective sleeve inside the top 3 inches of the condenser tubes. The unretouched photo shows the clean, uncorroded appearance of the "top-hat" after 14 months' continuous service. The titanium tube sheet, tubes and welds have essentially the same appearance as when installed . . . show evidence of being able to serve indefinitely.



**HIGH-VELOCITY STEAM** and biting hydrochloric acid were cutting the service life of cast-iron steam diffusers to less than 3 months at a Du Pont Pigments plant. Bronze and corrosion-resistant alloys were tried, without improvement. Then a diffuser fabricated from titanium was installed. This proved to be the answer. The photo shows the condition of the titanium diffuser after 2 years' service—a period ten times the average life of other diffusers. Compare the uncorroded appearance of the titanium diffuser with the cast-iron flange, which shows severe acid attack.

### A partial list of other environments where TITANIUM offers unmatched corrosion resistance . . .

| CORROSIVE CHEMICALS | CONDITIONS | POSSIBLE APPLICATIONS |
|---|---|---|
| Ferric Chloride | 0-30% at 100° C. | Process piping |
| Sodium Chloride | All Conc. at 100° C. | Kettles, heat exchangers |
| Chlorine-Saturated Water | Room Temperature | Proportioning equipment |
| Wet Chlorine Gas | 75° C. | Recovery equipment, electrolytic cells |
| Chromic Acid | 10% and boiling | Plating equipment |
| Sulphuric-Nitric Acid Mixture | 40% sulphuric, 60% nitric at 35° C. | Acid heaters, nitrators, auxiliaries |
| Calcium Hypochlorite | 6%-35° C. | Filter presses, processing equipment |
| Zinc Chloride | 20%-100° C. | Coils, pans, evaporators |

### TITANIUM MAY BE THE ANSWER TO YOUR CORROSION PROBLEM

If you're looking for a way to improve your product . . . or cut production and maintenance costs by extending the service life of essential equipment . . . it may pay you to investigate titanium. As a pioneer *supplier* of titanium sponge, Du Pont has the experience to offer you expert technical help with your evaluation tests . . . can put you in touch with manufacturers best equipped to work with you on your particular product or application. Considerable fabricating know-how and a wide variety of mill shapes are available now to help you use titanium to solve your corrosion problems. For more detailed information on titanium, just check the coupon below, or write: E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Wilmington 98, Delaware.

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## Contents Noted

metals otherwise lacking in these respects. Of the data presently available on characteristics of chromized metals, much of it is qualitative; for example, one specific material when chromized is acceptable for one specific application. In an attempt to generalize in order to indicate possibilities for various types of chromized materials, R. L. Samuel, N. A. Lockington and H. Dorner summed up characteristics of, and applications for, chromized metals in the third section of a three-part article, appearing in *Metal Treatment and Drop Forging* (British) last August.

### Corrosion resistance

Few systematic tests have been reported on the corrosion resistance of chromized metals under natural conditions, since it is approximately the same as that of stainless steels. Of the mineral acids, hydrochloric and sulfuric readily dissolve a chromized surface, unless solutions are very dilute and cold. Nitric acid has practically no action at all on concentrations. Chromized cast iron is generally considered unsatisfactory for corrosion-resistant applications, but in one test in 60% nitric acid containing ammonium sulfate at 100 F chromized cast iron was found to have a corrosion rate of 0.0014 ipy over a test period of 27 days. Phosphoric acid has a slow solvent action. In a boiling 2% solution, rate of attack is on the order of 0.002 ipy.

In organic acids chromized steel has a very low corrosion rate, dependent, of course, on concentration and temperature. It is therefore suitable for handling foodstuffs, including fruit and vegetable juices and milk. In other solutions, chromized metals show no attack in sulfurous acid, sodium bisulfite, or sodium sulfite solutions.

### Heat resistance

When chromium-diffused steel is heated in air, the surface oxidizes and interdiffusion between

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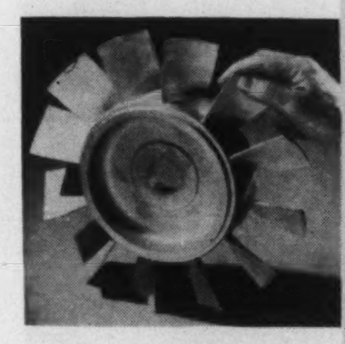
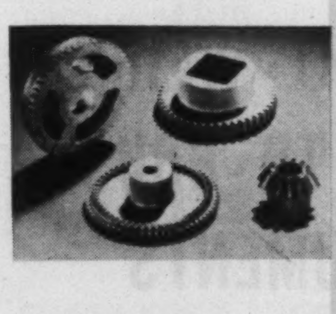
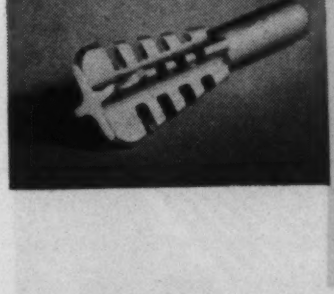


HIGH STRENGTH, LIGHT WEIGHT AND DIMENSIONAL ACCURACY are required in this 6000 rpm air impeller—which drives a generator in aircraft tow target. Universal makes them of aluminum alloy 356 TC poured at low temperature under vacuum in cast iron permanent mold with plaster core. Blade thickness decreases from 3/32 in. maximum to 0.015 in. at trailing edge—blade detail accuracy is possible only with one-piece plaster core. Impeller meets aeronautical materials and x-ray specifications.



COMPLEX GEARS with 90,000 psi minimum tensile strengths are plaster mold cast by Universal in aluminum, bronze and manganese bronze. Patented low temperature pouring process, developed for highly stressed castings, gives much denser structure and unusually high strengths in nonferrous alloys. Accurate detail and 1/32 in. sections are produced consistently.



DAIRY AND FOOD MIXER cast in 22% nickel brass alloy. Smooth surface finish, with no pit marks to catch bacteria, requires little polishing on this part. Dimensional tolerances of 0.005 in. are held in teeth and slots. Similarly produced parts are used in railroad passenger car equipment and packaging machinery. This alloy can be polished to a white finish similar to stainless.

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## Contents Noted

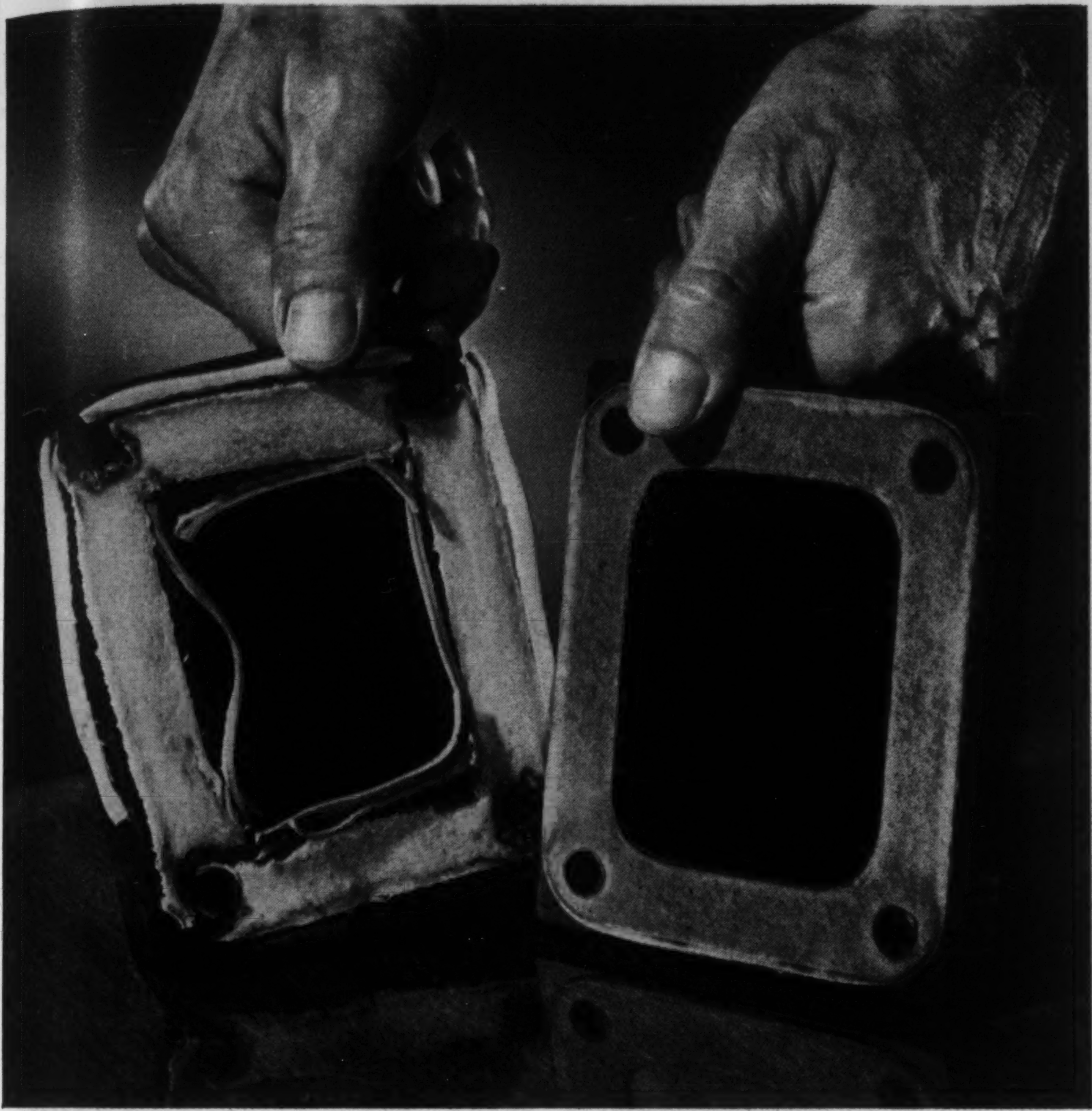
coating and core takes place. Chromized surfaces containing around 50% chromium are highly resistant to progressive oxidation at elevated temperatures, and the oxide films which first form adhere well and protect the surface. Up to 1550 F diffusion effect is not marked. Upon further increase in temperature, particularly above 1650 F, chromium continues to diffuse inwards and iron diffuses towards the surface, so that surface chromium concentration is gradually reduced. At higher temperatures, impoverishment of chromium in the surface results in faster oxidation and the material breaks down earlier than would be expected from the behavior at lower temperature.

Uses for chromized steels at various temperatures are somewhat standardized. At 575-750 F they are used for parts for ovens and infrared dryer panels. Screws, nuts, and bolts do not seize by rusting so that cleaning and reassembly is simple. Heat exchanger tubes, exposed to air containing sulfur dioxide at 1100-1200 F show no measurable increase in weight. Only a discoloration is noticeable. At 1500-1650 F chromized mild steel sheet parts are used in place of chromium irons, for gas cooker grill frets.

### Wear resistance

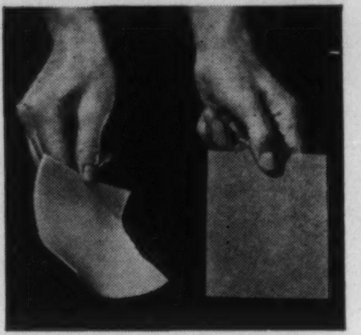
Although surfaces of chromium-diffused low carbon steels have good frictional characteristics and outer surfaces may be quite hard, a medium carbon or high carbon steel is usually specified when wear-resistance is required. A thin coating rich in chromium carbide is obtained, having a hardness greater than Rc 70. Sometimes a low carbon steel is carburized before chromizing, but the tendency for the carbon case to rediffuse during the second treatment must be kept in mind.

Unless the surface is to take little load, care should be taken to minimize decarburization of the steel by the reducing atmosphere in the box. As a very thin



Cold flow resistance of TEFLON* and reinforced TEFLON (DUROID 5600) was tested at 700° F., under a torque of 35 pounds and a flange pressure of 1,000 p.s.i. After 2 hours the flanges were cooled and the bolts retightened. The flanges were then exposed to the heat for another 2 hours. Results are as pictured. The gasket of TEFLON (left) extruded extensively on all edges and lost all bolt torque. DUROID 5600 did not extrude and retained 15 pounds bolt torque, demonstrating significantly improved resistance to cold flow.

## Greater Resistance to Heat Distortion



TEFLON (left) distorted badly when subjected to 720° F. and then cooled. Reinforced TEFLON (DUROID 5600) exposed simultaneously to the same temperature retained flatness, demonstrating greater dimensional stability at high temperatures.

### SOME IMPORTANT TEST VALUES

| | |
|---|---|
| Tensile Strength, MD, psi | 2500 |
| Tensile Strength, CMD, psi | 1500 |
| Compressibility, 5000 psi, % | 8 |
| Thermal Expansion Coefficient per °F., 73-140°F. | $2.7 \times 10^{-5}$ |
| Heat Distortion Temperature, °F. | |
| 66 psi | 500+ |
| 264 psi | 500+ |
| Deformation under Load, % | |
| 1200 psi | 2* |
| 2000 psi | 3* |
| Coefficient of friction against polished steel, | |
| static | .21 |
| kinetic | .14 |
| Specific Gravity | 1.90 |

*Made up of actual flow and also of compression under load. Data to indicate breakdown between these two portions is being obtained.

# ROGERS REINFORCES "TEFLON" TO REDUCE ITS COLD FLOW

Rogers DUROID 5600 is a combination of TEFLON and inert fibers, blended into an homogeneous sheet material. This new material is not a replacement or a substitute for TEFLON, but rather an extension of it. TEFLON has better electrical characteristics and dry lubricating qualities. DUROID 5600, however, has much of TEFLON'S resistance to chemicals, and is greatly superior to TEFLON in resistance to cold flow and heat distortion.

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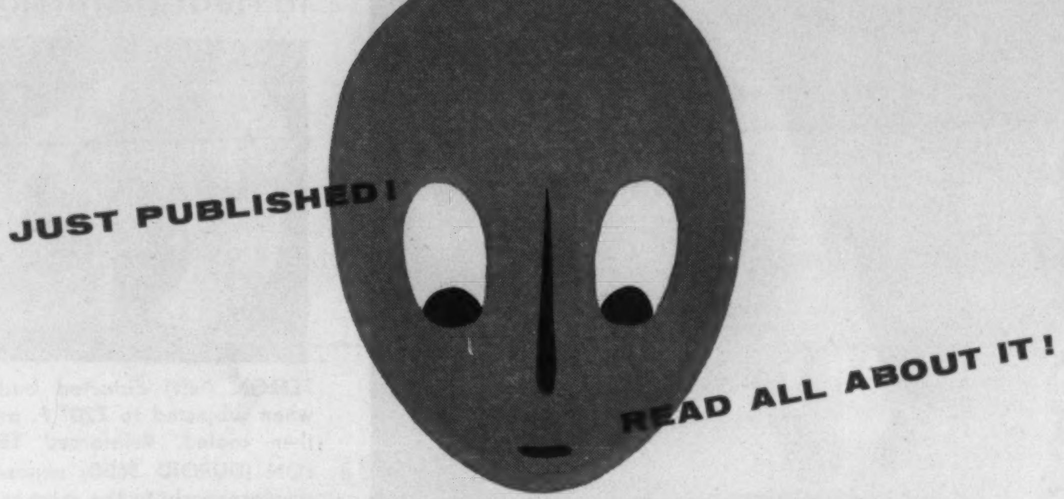
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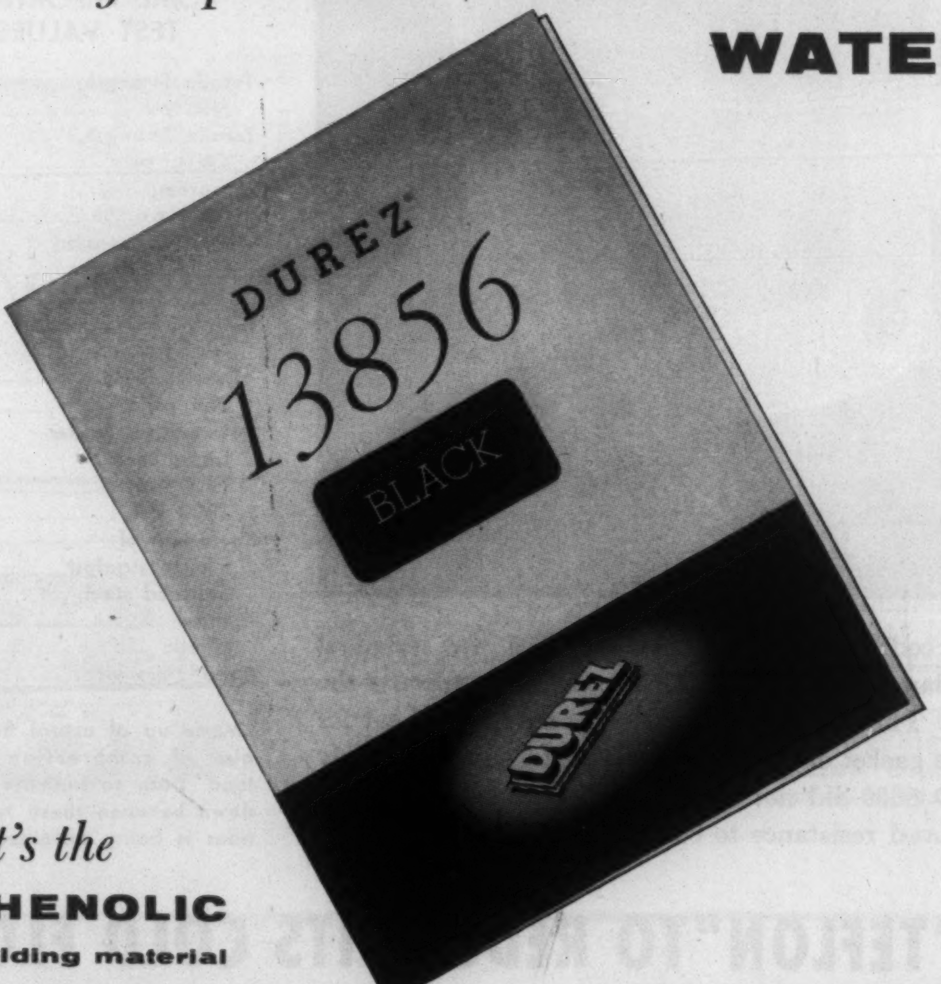

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## Contents Noted

coating is sufficient to impart wear-resistance, the zone just beneath the coating can supply the carbon required to form chromium carbide without itself being noticeably decarburized.

Applications for chromized materials in wear resistance applications include weighing-machine parts where wear-resistance and corrosion-resistance are required on working parts such as knife edges and vee blocks. Steel orifice plates were chromium-diffused and fitted to fuel injection burners for marine engines operating on creosote pitch. The plates were tested in service on liners for over two years and proved highly superior to untreated plates used previously. Cast steel cutters, chromium-diffused and heat-treated, are used on chromium-plated brass with a performance estimated at five times the life of untreated tools.

### Cobalt-Iron-Chromium Alloys Have Low Thermal Expansion

Materials with extremely low coefficients of thermal expansion are necessary for use in tools and machines such as thermostatic instruments and measuring devices. Generally, fused quartz, Invar and some ceramics have been used, but of these only Invar is metallic and it is subject to small but significant dimensional changes over long periods of time. The National Bureau of Standards has found that the thermal expansion of certain cobalt-iron-chromium alloys is extremely low and nearly constant between 65 and 140 F. The results of the work have been published in a research report by P. Hidnert and R. K. Kirby of NBS.

A cobalt base alloy with 36.6 iron, 8.9% chromium and balance cobalt was found to have a coefficient of expansion of less than 1 x $10^{-6}$ per deg C over the temperature range of 65 to 140 F. The authors report that the low expansion of such alloys is very

800%
increase in one year

# ...in the use of ZINC DIE CASTINGS

A prime factor in the rapidly growing use of die castings has been the recognition of the process for what it has proved itself to be: The shortest distance between raw material and finished part. The automotive industry has been especially alert in taking advantage of this high speed production tool. 1955 models use eight times as much zinc die casting in front-end assemblies as the '54 models did.

Since this industry has been the top user of zinc die castings right along — taking more than half the total last year — the impressive swing to more zinc is significant. It definitely establishes the fact that zinc die castings are less costly to produce than those based on any other metal. Because of its low melting point, zinc can readily be cast in the most highly automatic machines. The more automatic and the more rapid the casting cycle, the greater the savings on costs. The smooth, as cast surface of zinc alloy castings is practically ready for plating. This gives zinc an advantage over all other die casting alloys for use as decorative objects and trim. In addition to all of the eye-catching chromium plated zinc die castings, the functional out-of-sight carburetor, fuel pump and windshield wiper housings continue to be zinc die cast at lowest cost.

The utilization of zinc die castings is also making rapid advances for important components in home appliances, hand tools, instruments, electrical equipment, business machines and innumerable other products which, were it not for zinc die castings, would be neither as attractive in appearance, as rugged, nor as low in cost.

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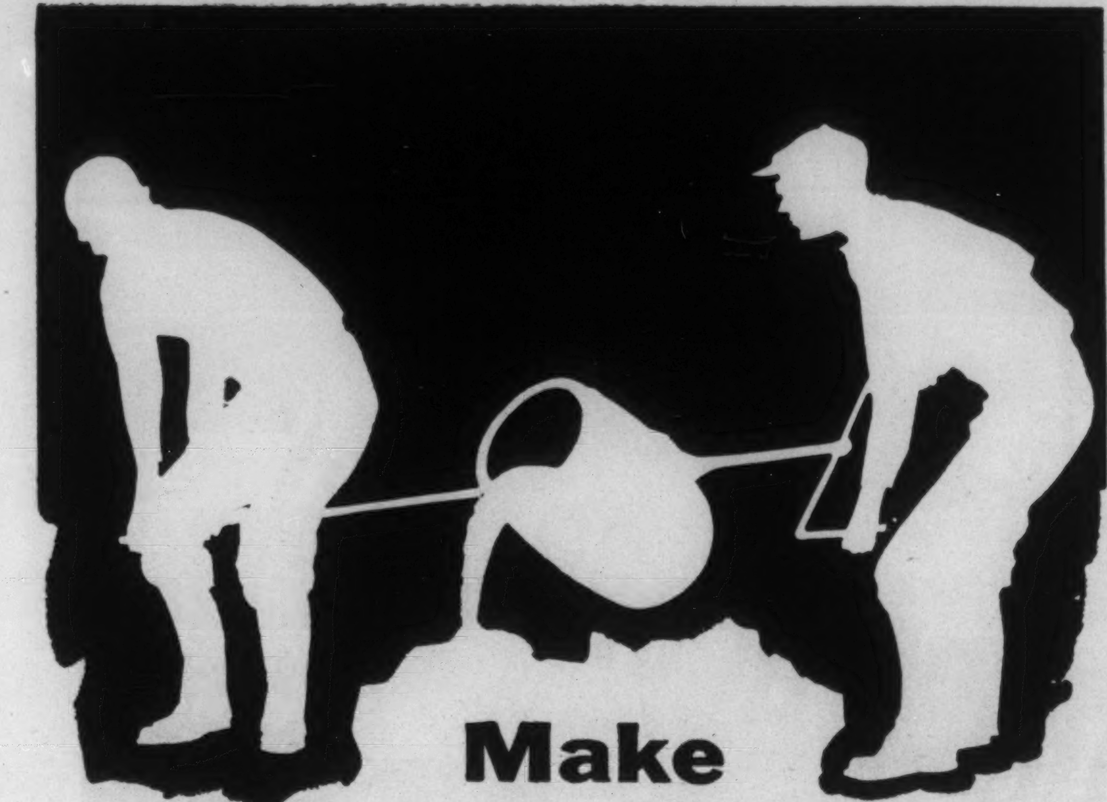

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Tenzaloy, a product of Federated research, is a self-aging alloy of the aluminum-zinc-magnesium type. It reaches full strength after a few days aging at room temperature. No special casting precautions or facilities are required.

Tenzaloy castings have excellent machinability. They can be anodized to a superior white color. Tenzaloy is one of the few casting alloys that can be brazed at high temperature. It has corrosion resistance equal to or better than the aluminum-silicon alloys.

If your heat treating facilities are inadequate or too costly, or if you are paying for outside work, or if you are casting large and complex aluminum shapes which cannot be conveniently heat treated, call Federated for more information on modern Tenzaloy. Any of our 13 plants and 23 sales offices across the country is ready to help.

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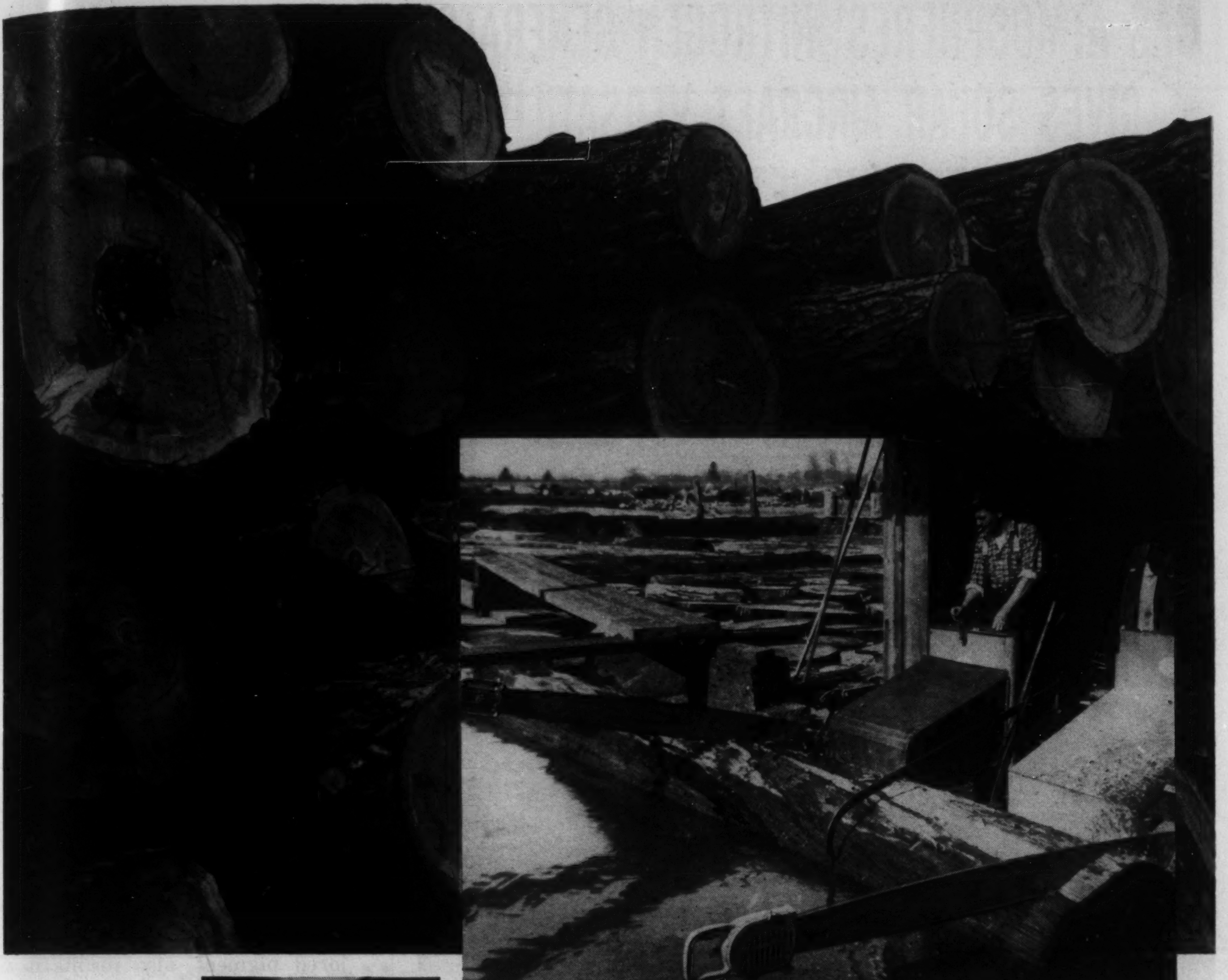
## Contents Noted

sensitive to small variations in chemical composition. Also, some of them undergo a transformation on cooling at low temperatures. Tests at the Bureau covered a temperature range of −310 to 1800 F.

Alloys with chromium contents ranging from 8.6 to 9.2% have very low rates of expansion at room temperature. Some of them have coefficients less than those of fused quartz and ordinary Invar between −75 and 140 F; however, on cooling to lower temperatures they undergo a first-order transformation of the martensitic type resulting in a low-temperature phase with a much higher rate of expansion. Temperatures at which these transformations start are as high as 14 F and decrease with increasing amounts of chromium. The reverse transformation, which reproduces the high temperature phase, starts at about 1100 F but is not complete until the alloy is heated above 1600 F. Further work will have to be done to determine physical and mechanical properties of the alloys at various temperatures to pinpoint their practicability for commercial use.

### How Car Finishes Deteriorate

Accompanying the recent developments in automotive finishes, which have produced a rainbow of colors in late model cars, have been intensified efforts to improve durability of the finishes. A necessary prerequisite to improvement in the finishes is an understanding of the mechanism of degradation. In other words, you must find out how a film deteriorates before you can develop methods of preventing it. In the July issue of the *ASTM Bulletin* two papers discuss results of work done to determine deterioration mechanisms for the two basic types of finishes used on cars today. R. L. Saur of General Motors Research Labs describes the process as it occurs in automotive lacquers while E. B. Fitzgerald



▲ L-M pond-type chain saws "bucking" log for a veneer plant.

◀ Close-up of MAX-EL alloy steel chain saw bar, showing depth of heat treatment for tougher, longer-lasting bars.

# it takes MAX-EL Alloy Steel to take a beating like this

Ram the flying teeth of a chain saw against a heavy log – and watch the sawdust fly! But don't forget — backing up that speeding chain is a bar that has to absorb all the shock . . . yet keep the chain lined up accurately, dependably.

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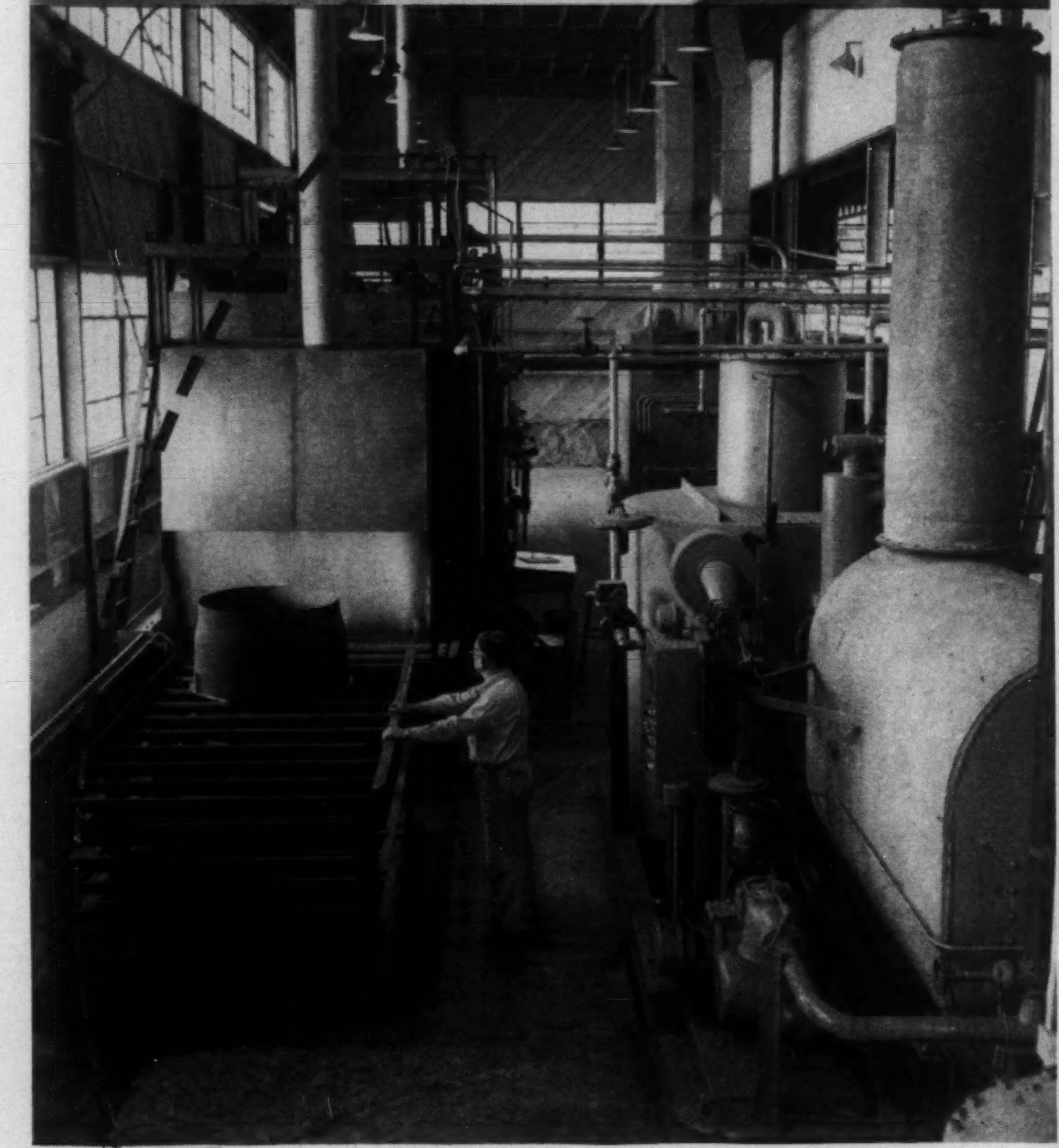
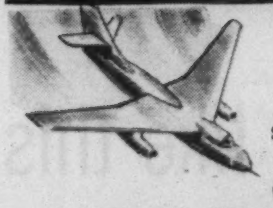
GAS ATMOSPHERES' NITROGEN GENERATOR GIVES SOLAR AIRCRAFT VERSATILITY IN HEAT TREATING JET ENGINE PARTS





"We can certainly say this: 'We are very happy with the Gas Atmospheres' unit.'" This from an executive of the Solar Aircraft Co., San Diego, in reference to a Gas Atmospheres' 8000 cfh low ratio nitrogen gas generator that furnished the nitrogen for one of the largest controlled atmosphere furnaces west of the Mississippi.

Heat treating housing bodies and other parts for the Wright J65 jet engine, Solar engineers are particularly impressed with the versatility of the unit. They have operated it with gas-air ratios as low as 5.5-1 and as high as 9-1 with consistent gas composition at all ranges. "The unit operates continuously with a minimum of maintenance, and its simplicity makes training personnel an easy matter," they state

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of E. I. du Pont de Nemours discusses degradation of alkyd enamels.

**Photochemical lacquer chalking**

Saur explains that light, oxygen and water vapor all contribute to lacquer gloss loss, the rate being somewhat dependent on relative amounts of each component and on the wavelength of light. The film gradually loses thickness on exposure probably due to erosion of the nitrocellulose vehicle from the surface. The erosion is due partially to evolution of gases and partially to removal, upon washing, of water-soluble deterioration products. As the vehicle is eroded the pigment in the surface becomes progressively more exposed. Colored pigments generally being of smaller particle size are also sloughed off with the vehicle, thereby exposing larger white pigment particles. The resulting roughened surface scatters reflected light and results in the loss of both gloss and reflected image resolution. This light scattering, coupled with loss of colored pigment, also results in a whitened surface.

The probable mechanism by which the nitrocellulose vehicle decomposes is also explained by Saur. Cellulose nitrate, in presence of light, is hydrolyzed to cellulose and simultaneously oxidized to liberate certain gases, including nitrogen dioxide. $NO_2$ as well as atmospheric oxygen in the presence of light is capable of oxidizing cellulose to celluronic acid, the major solid deterioration product identified. As both cellulose and celluronic acid are somewhat water-soluble, action of rain and dew further exposes surface pigments and continually renews the vehicle surface for further deterioration. The author concludes with the caution that his is only a preliminary report and suggests that further work must be done.

**Photooxidative alkyd chalking**

E. B. Fitzgerald describes the mechanism of loss of gloss and

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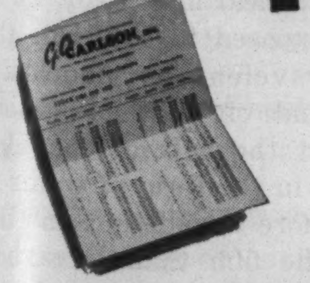

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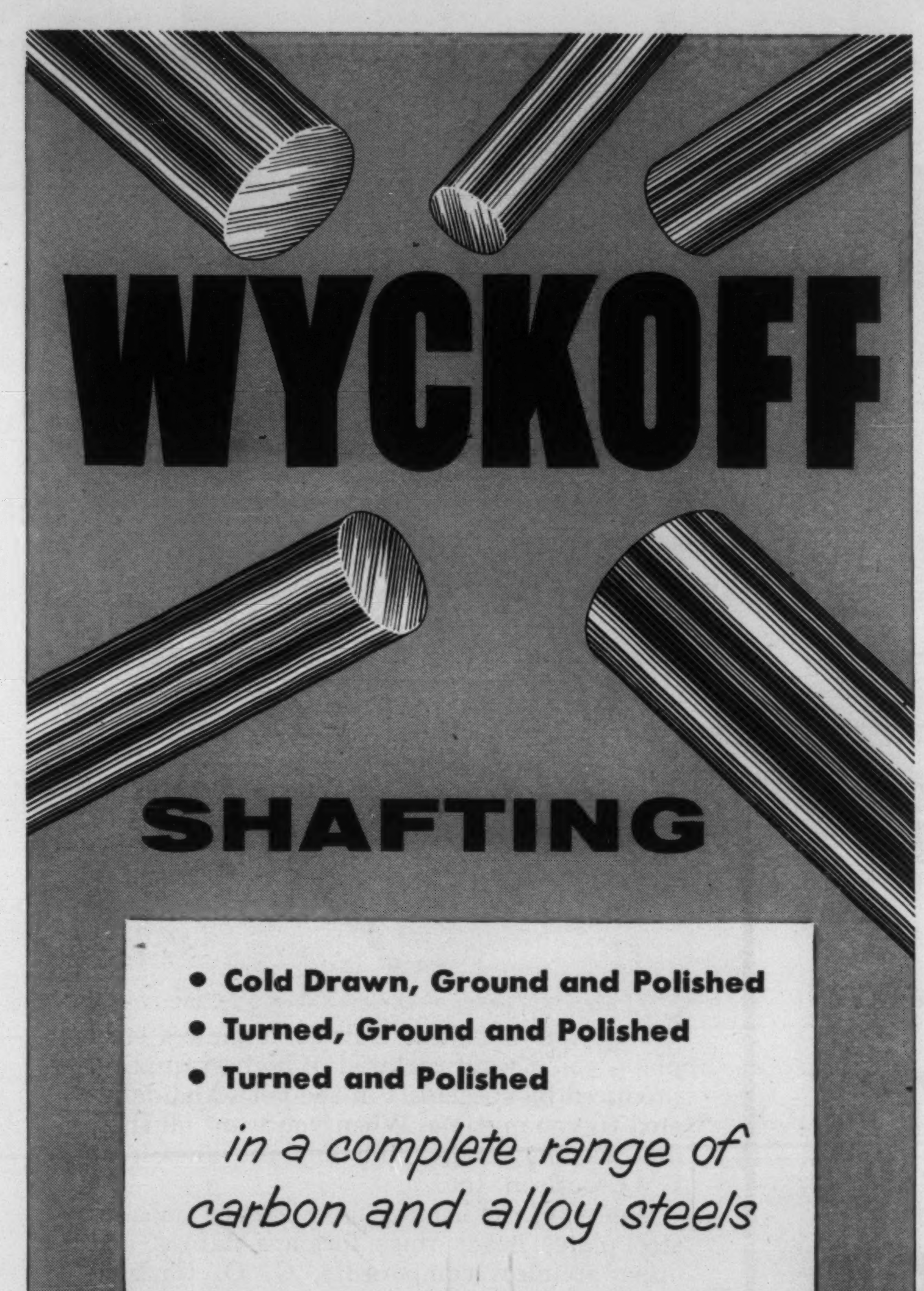

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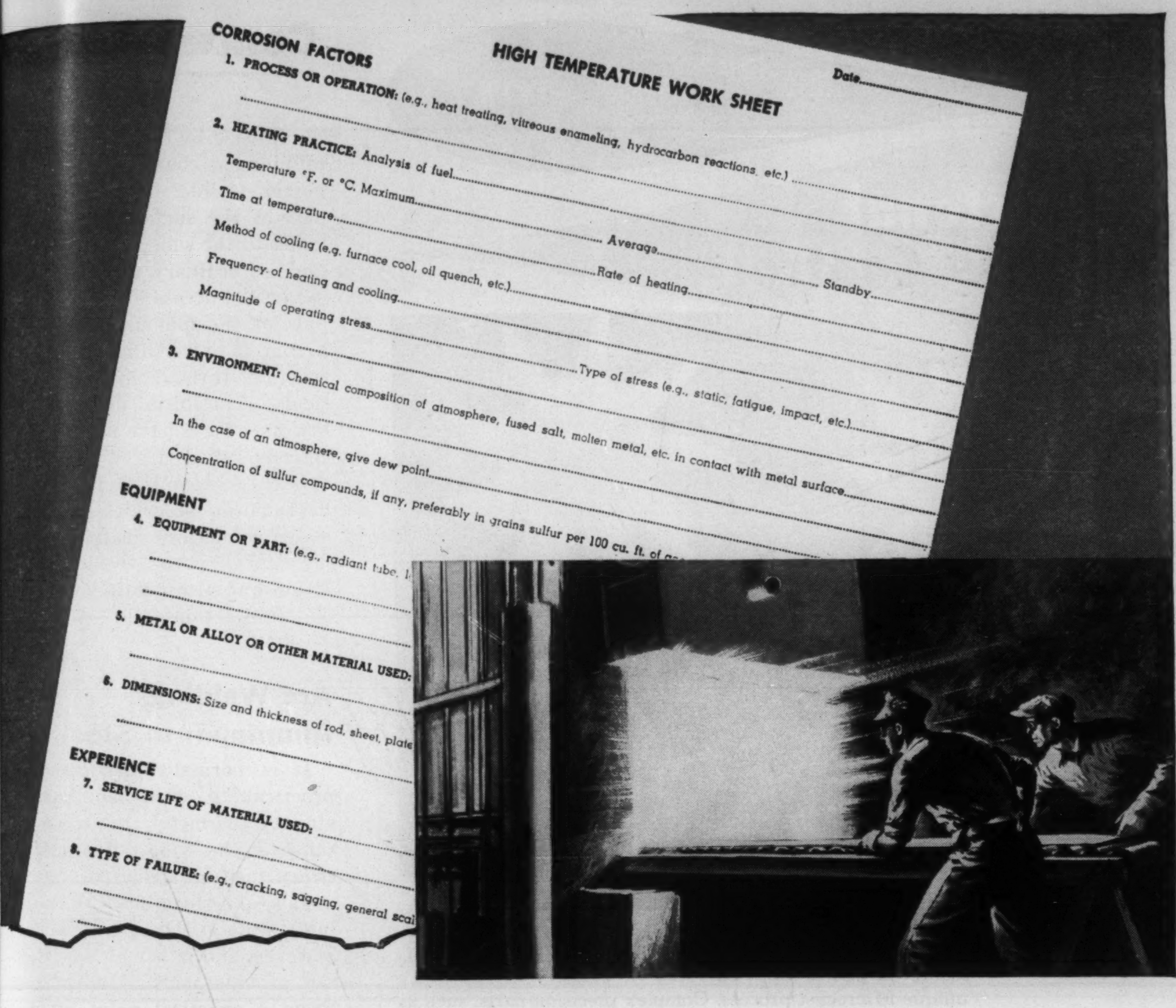
chalking as occurring in alkyd enamels used in automotive finishes. The initial step in degradation of drying oil alkyd enamels occurs during the cure stage of film formation. Oxygen attacks the unsaturation in the oil and forms hydroperoxides, which can decompose in side reactions to produce hydroxyl carbonyl and other oxygenated groups. The carbonyl groups absorb strongly in the near ultraviolet and significantly at longer wave-lengths.

Upon exposure to sunlight, these complex ketones immediately begin producing carbon monoxide, free radicals, new olefins and lower ketones. If oxygen is present, the free radicals are oxidized to new photolyzable compounds; the newly formed olefins are subject to repetition of the hydroperoxidation process and the lower ketones continue to be photolyzed until the chain in which they originally existed is consumed. While all of these reactions start in the oil molecule, their damage spreads by repetition until the glyceryl phthalate ester is attacked and ultimately converted into volatile products.

Long before the film is entirely consumed, the effects of this complex chemical process can be observed as physical changes in the film. Very short wavelengths are completely absorbed in a thin surface layer and repetitive reactions proceed rapidly through complete alkyd units of this layer. Thus, if incident light is entirely short in wavelengths, the major physical effect is an erosion of the surface which appears as "chalk" if the film is pigmented, or as slight dulling in a clear film.

When exposed to sunlight, the longer wavelengths penetrate deeper and initiate reactions throughout the bulk of the film. Hydrogen in the form of water is evolved more rapidly from the bulk of the film than is carbon in the form of oxides and volatile compounds. As a result, shrinkage increases in density, embrittlement and yellowing occur in the bulk of the film. These effects are



**CORROSION FACTORS**

**HIGH TEMPERATURE WORK SHEET**

Date

**1. PROCESS OR OPERATION:** (e.g., heat treating, vitreous enameling, hydrocarbon reactions, etc.)

**2. HEATING PRACTICE:** Analysis of fuel

Temperature °F. or °C. Maximum Average Standby

Time at temperature Rate of heating

Method of cooling (e.g. furnace cool, oil quench, etc.)

Frequency of heating and cooling

Magnitude of operating stress Type of stress (e.g., static, fatigue, impact, etc.)

**3. ENVIRONMENT:** Chemical composition of atmosphere, fused salt, molten metal, etc. in contact with metal surface

In the case of an atmosphere, give dew point

Concentration of sulfur compounds, if any, preferably in grains sulfur per 100 cu. ft. of ga

**EQUIPMENT**

**4. EQUIPMENT OR PART:** (e.g., radiant tube, l

**5. METAL OR ALLOY OR OTHER MATERIAL USED:**

**6. DIMENSIONS:** Size and thickness of rod, sheet, plate

**EXPERIENCE**

**7. SERVICE LIFE OF MATERIAL USED:**

**8. TYPE OF FAILURE:** (e.g., cracking, sagging, general scal

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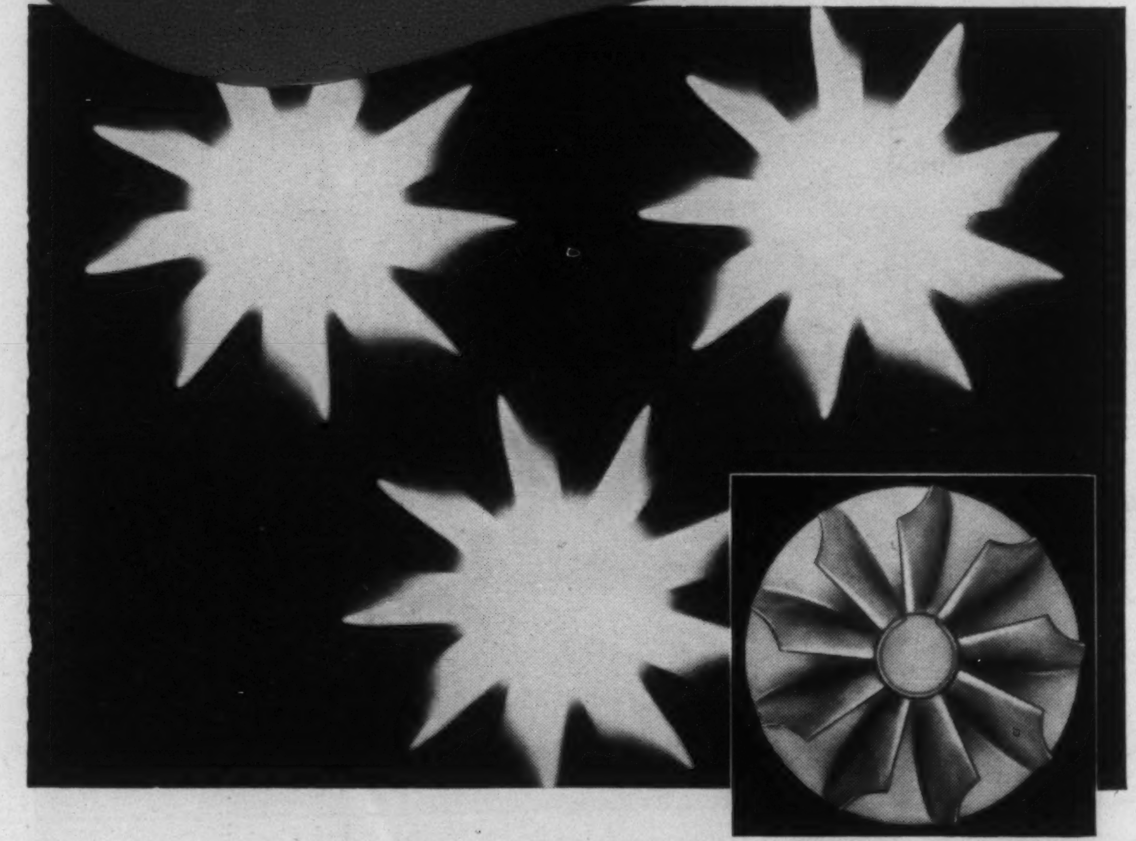
INSIDE STORY

Austenal Quality Control



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diminished by the screening effect of pigment, but radiation in the longer visible and near-infrared part of the sun's spectrum penetrates to the substrate interface in films of ordinary thickness.

Limited access of oxygen in the bulk of the film undoubtedly has a role in governing sequence of reactions throughout the film, particularly in initial drying stages, but its effects have not been specifically studied. Water vapor appears to have little influence on degradation processes, but liquid water accelerates chalking by the physical effects of swelling and solution and also possibly by chemical interaction.

## Arc Welding Aluminum to Steel

It is normally considered impractical to weld aluminum to steel by the metal arc process, because of the wide differential between melting points of the two metals, and the difficulty in selecting a suitable flux. It can be done, however, and in some applications can provide unusual advantages. From a practical point of view, everything depends on what the joint is required to do. For example, steel bolts can be welded to an aluminum busbar, or steel studs can be welded to a prefabricated aluminum building in order to join it to a steel structure. In the Jan.-Mar. issue of *The Welder* published by Murex Welding Processes Ltd., England, E. H. S. van Someren, describes briefly some techniques used and results obtained in arc welding aluminum and steel.

The problem of differential in melting points can be overcome where a small mass of steel is used with a large mass of aluminum. The problem of fluxes is more difficult; fluxes which must be used for welding aluminum are not good fluxes for steel, and steel exposed to their action cannot be welde to aluminum. This difficulty ca be overcome by thoroughly cleaning the surface of the steel an coating it with a film of spraye

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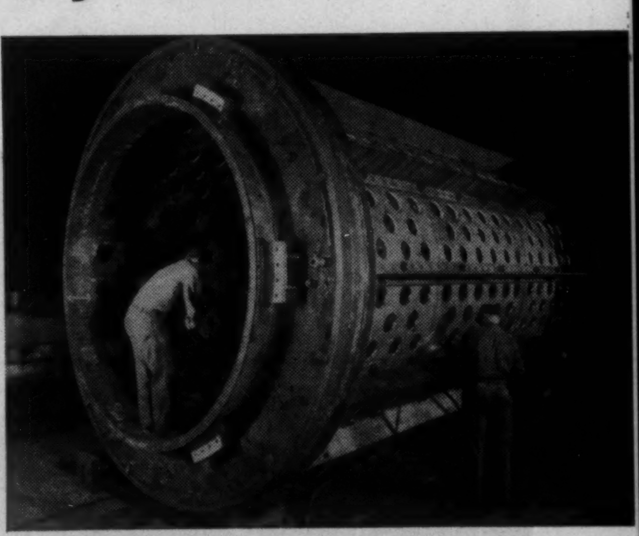

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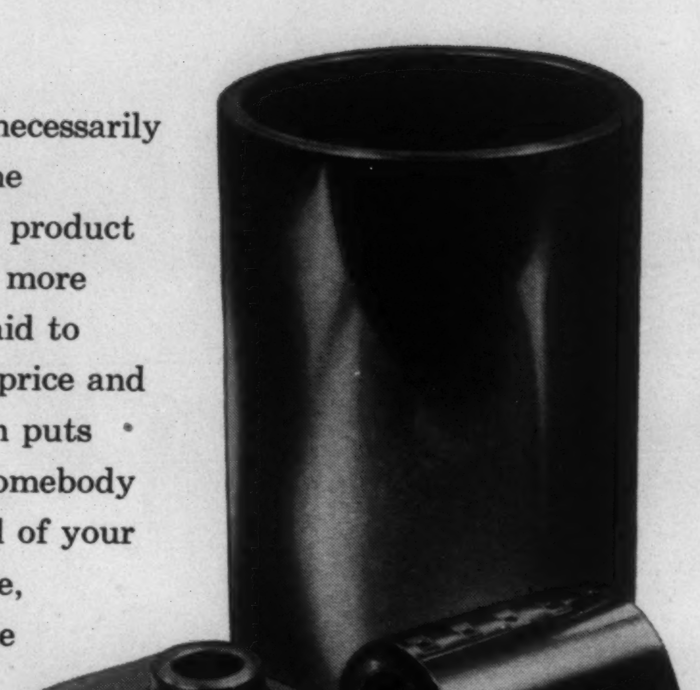

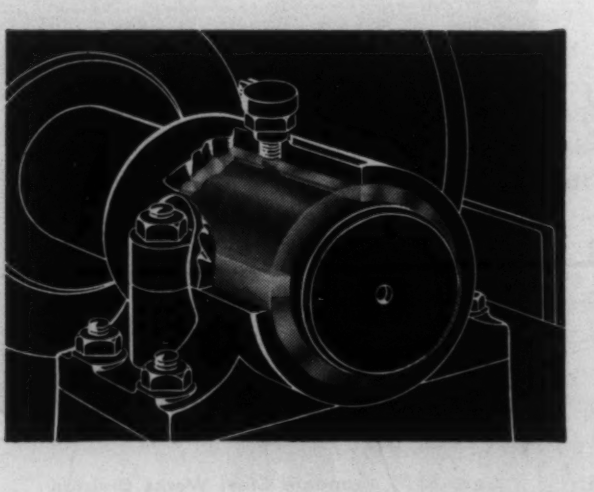

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## Contents Noted

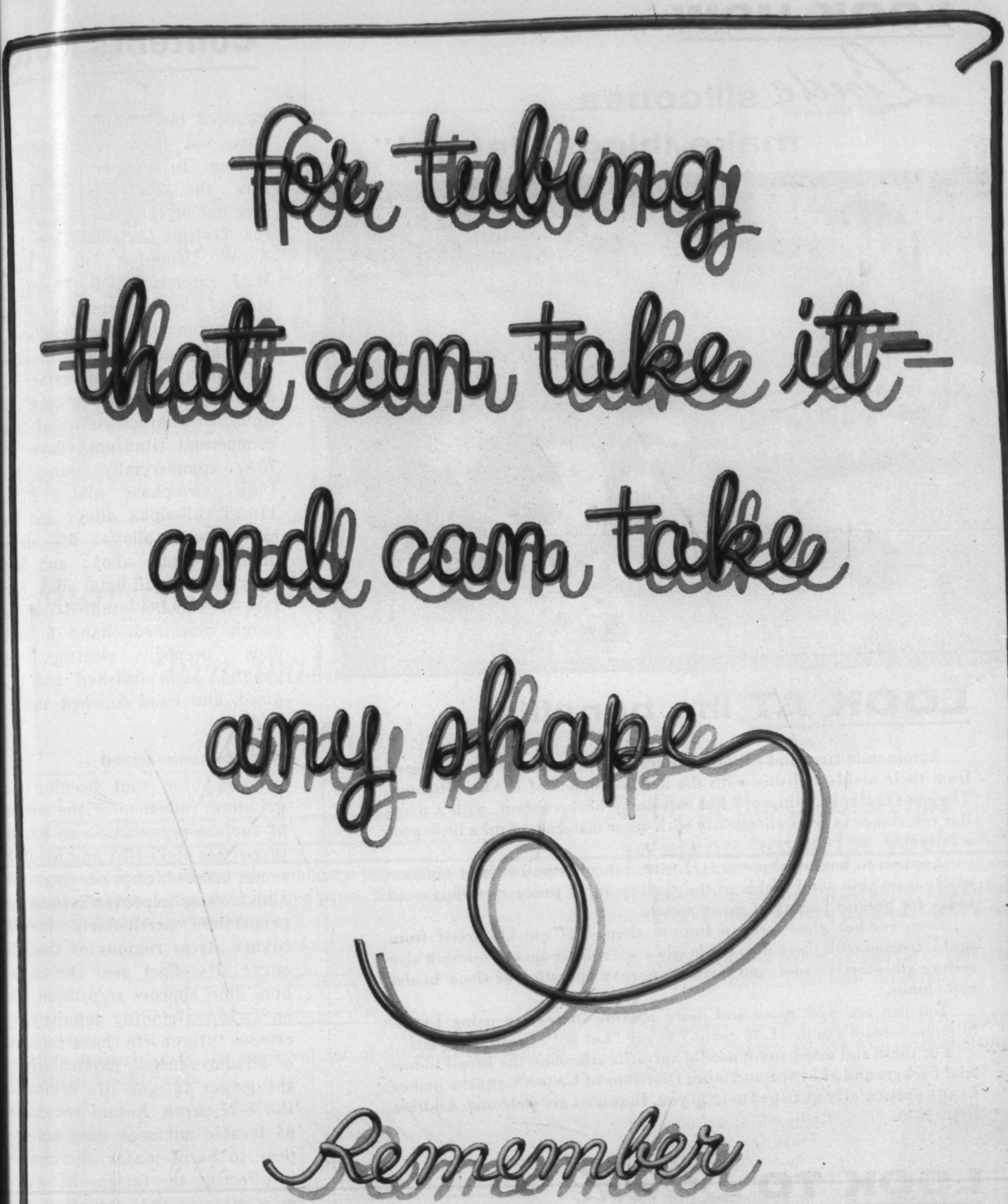
aluminum about 0.005 in. minimum. Aluminum can then be welded to the aluminum-coated steel with an aluminum-silicon electrode.

A number of fillet welds between steel and aluminum have been made in this way on both pure aluminum and on common magnesium-silicide type alloys. Some of the joints were broken and the interface showed appreciable attack by the aluminum on the steel. Increasing this attack by preheating the steel is undesirable since the aluminum-iron alloy thus formed is rather brittle. In tests to determine strength of joints formed in this way, $3/8$- and $1/2$-in. steel bars were welded t aluminum. In a tensile testing machine, joints between the smalle bars and aluminum broke at load between 500 and 1500 l while welds on the larger bar broke at a load between 1000 an 2400 lb.

Corrosion of aluminum is liabl to be accelerated in the presenc of other metals. This is particu larly true in cracks and crevice where moisture can lodge an build up corrosion products. I steel bolts are welded to alum num and then bolted to a ste girder or other support, the should either be left exposed s that any corrosion product can b seen and washed off, or else the should be thoroughly protecte with a priming paint and tw coats of good finishing paint. I conclusion the author warns th though aluminum can be succes fully welded to steel by the met arc process, each case should b carefully considered on its meri before welding is attempted.

### Effect of Surface on Fatigue of Titanium

The surface condition of va ous metals can have an importa effect on the behavior of th metals during fatigue stressi While fatigue characteristics some titanium alloys have be studied, influence of surface c dition was believed to be p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## Contents Note

nounced but unknown, and da have not been from repetiti testing. In a paper delivered b fore the Fifty-eighth Annu Meeting of the American Socie for Testing Materials last Jun A. W. Demmler, Jr., of Alco M. J. Sinnott and L. Thomasse both of the University of Mich gan, summarized the results of study made to determine the effe of various methods of surface co ditioning on rotating-beam f tigue life characteristics of thr commercial titanium alloys: T 75A, commercially pure; R 130B, two-phase alloy; RC- 110AT, all-alpha alloy; and tw experimental alloys: 6% alum num, all-alpha alloy; and 30 molybdenum, all-beta alloy. Su face treatments studied includ rough machined, hand finishe shot peened, electropolishe ground, hand finished and o dized, and hand finished and trided.

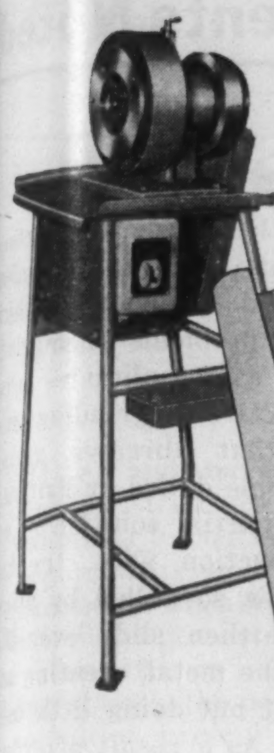
### Results summarized

Except for shot peening a grinding, influence of the meth of surface preparation on fatig properties of Ti-75A and RC-13 is not marked. Shot peening of alloys tested improves fatigue l properties, particularly in higher stress regions of the S curve. Its effect near the end ance limit appears significant o on Ti-75A. Grinding definitely creases fatigue life characterist of all alloys tested, particularly the longer fatigue life region the S-N curve. Actual roughn of treated surfaces does not pear to be of major significa in affecting the fatigue life ch acteristics in that its effect masked in this study by ot variables.

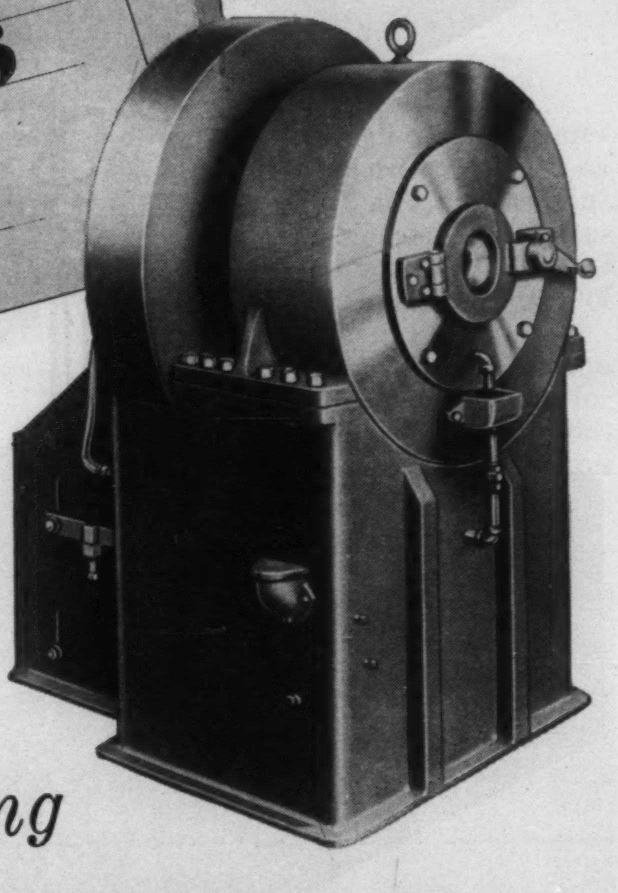
The authors also report that ternal heating encountered dur testing of Ti-75A is believed be due principally to presence dissolved hydrogen.

The standard deviation in cles to failure at a given st for a given surface condition of the same order of magnit as reported for other metals.

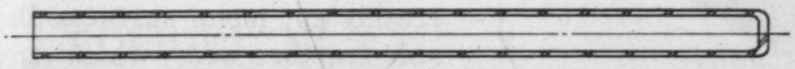
*(More Contents Noted on p. 19*



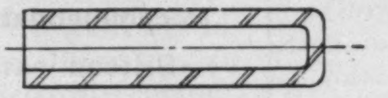
# Swaging Success Stories



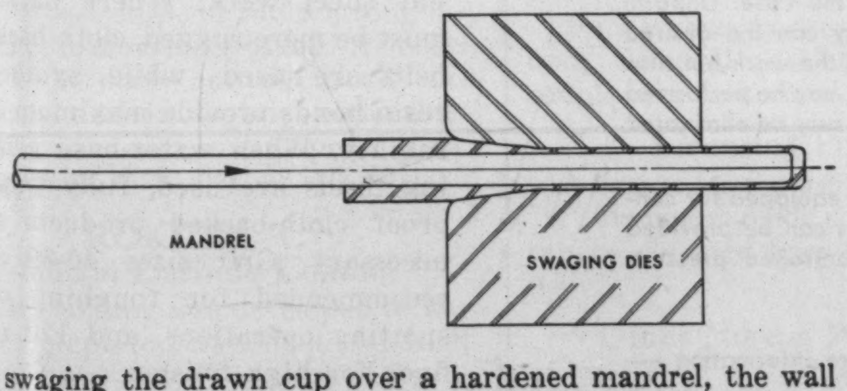
## *Fabricating long, thin-walled cups... by Mandrel Swaging*



This extra deep, thin-walled cup would be impossible to make by the usual method of deep drawing in a press. But swaging provides an easy solution to the problem.



A cup is drawn having the same volume of metal in the wall as the desired finished cup.



By swaging the drawn cup over a hardened mandrel, the wall is thinned and the cup lengthened to required proportions.

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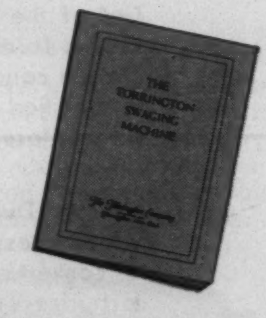

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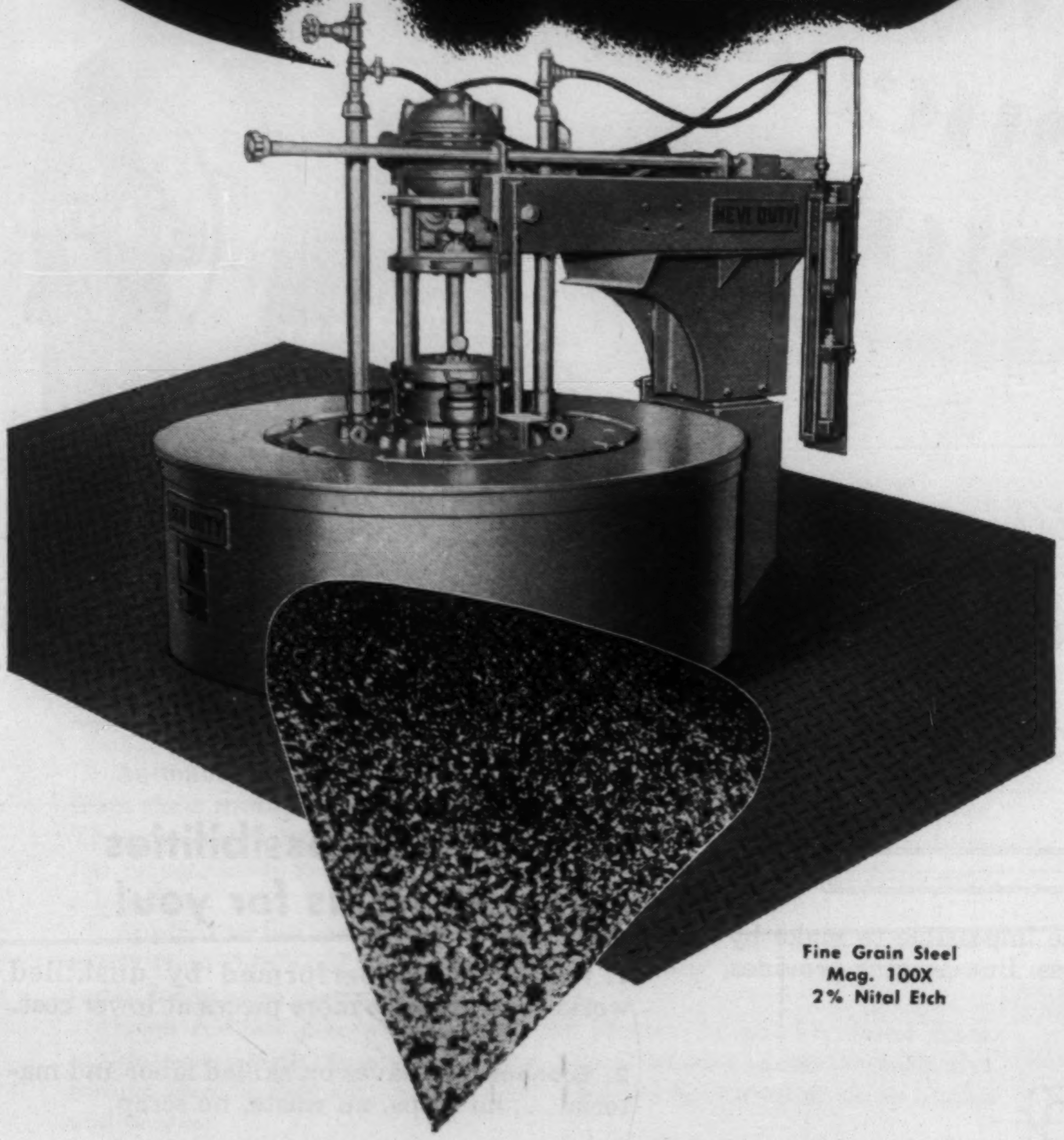

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# Contents Noted

## Grinding Titanium

Unlike other structural metals, titanium has unusual chemical and physical properties which pose certain problems when grinding it with coated abrasive belts. It is so reactive at grinding temperatures that abrasive grains rapidly become dulled or flattened because of partial solution in, or chemical reaction with, the hot metal. Grains so dulled by attritious wear, then slide over the surface of the metal, creating additional heat but doing little useful cutting. As a result of extensive investigations at Behr-Manning Div. of the Norton Co., Dr. H. N. Dyer reports recommended procedures and practices for grinding titanium with coated abrasive belts.

According to Dr. Dyer, successful grinding of titanium with abrasive belts depends on reducing attritious wear by lowering temperatures at the grinding point and using grinding fluids which form protective films over freshly cut metal surfaces. Desirable fracture wear, which exposes fresh cutting edges is promoted by using right belts at righ speeds with right contact wheels and grinding fluids.

### Recommendations

Silicon carbide-coated abrasives give the best results. Paper backed belts, used dry or with oi or grease, are suitable for som flat sheet work. Where backin must be more rugged, cloth-backe belts are used, while syntheti resin bonds provide maximum durability. When water-base grinding fluids are used, fully waterproof cloth-backed products ar necessary. Grit sizes 40-80 ar recommended for roughing an spotting operations, and 120 an finer for high finishes.

The contact roll supporting th belt should be as small in diamete and as hard as practicable, providing almost line contact an high unit pressure between abrasive belt and work. A very lo belt speed reduces temperature at the grinding points, retard

# Three NEW Refractory Products For Reaction Motors

IN THIS "high temperature age," when industry is asking for materials with ever higher melting points, the requirements of reaction motors are extremely demanding.

Depending upon extreme temperature differentials in converting heat into useful work, the power plants for jet propulsion present unique time-vs.-temperature problems. To meet these problems, component materials must be able to withstand not only very high temperatures but also other factors such as thermal shock, erosion, corrosion and oxidation.

Aware of these requirements, Norton Company has for years been engaged in a program of experimentation, development and testing of various materials. A number of these have proved highly satisfactory for reaction motor and similar applications; in particular, the three described below.

### ROKIDE* "A"
### Aluminum Oxide Coating

A hard, adherent, refractory oxide coating, pure white in color and containing about 98.6% $Al_2O_3$. It has been successfully applied on ceramics, glass, and certain plastics but particularly on metals in thicknesses of .005" to .050", and greater in special cases. This crystalline oxide coating protects the base material under high temperatures and erosion conditions, and its alumina, being harder than the hardest steel, provides strong resistance to abrasion. ROKIDE "A" coating is thermally and electrically insulating and is slightly permeable. This coating and coating process are covered by U. S. Pat. #2,707,691.

### ROKIDE "C"
### Silicon Carbide Coating

This coating was developed to improve graphite components for high temperature use. It consists of a protective layer of pure CRYSTOLON® silicon carbide, of dark gray or gray-green color, formed at high temperature on the graphite, to protect it and increase its resistance to erosion and oxidation. The coating varies between .002" and .030" but is usually around .010". It reacts integrally with, and becomes a part of, the graphite surface. A considerable part of the coating, therefore, is chemically derived from the graphite itself. ROKIDE "C" coating has excellent thermal shock resistance and extreme resistance to abrasion. It is slightly permeable. This coating process is covered by U. S. Pat. #2,667,627.

### CRYSTOLON® "N"
### Silicon Carbide Products

These are monolithic bodies, kiln-fired at high temperature and molded to close dimensions in a wide variety of shapes and sizes. They have greater resistance to mechanical and thermal shock than most ceramics and, compared to other commercial refractory products, are very strong. CRYSTOLON "N" material is dense and extremely refractory. Products made of it have been used successfully at estimated temperatures as high as 5000°F for varying periods of time.

### Applications

Typical applications for which these products have shown exceptional promise:

*Rockets:* nozzles, motor tube linings, thermal barriers.

*Guided Missiles:* vanes, skin protection, motor components.

*Ram Jets:* tail pipe lining.

*Gas Turbines:* inner combustion chamber lining, cross fire tube lining, flap nozzle coating, housing and shroud ring insulation.

*Miscellaneous:* burner parts protection, electrical insulation, thermocouple tube protection.

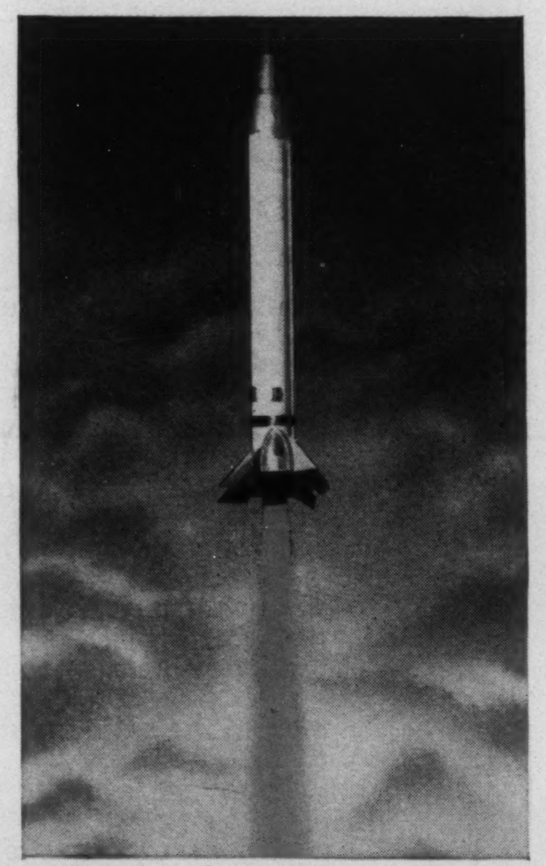
### Licensing Policy

A license for the use of the ROKIDE "A" aluminum oxide coating process can be obtained from Norton Company.

### Other Norton Products

of interest to designers and builders of reaction motors include refractory ceramic materials of commercial type, including fused stabilized zirconia, various CRYSTOLON products, MAGNORITE® fused magnesium oxide products and ALUNDUM® fused aluminum oxide products. Norton also makes a number of refractory carbides, borides and nitrides. These high-melting materials, which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory ℞'s — refractories *engineered and prescribed* for the widest range of uses.

For further information on Norton products for reaction motors — or for other applications — write, mentioning your requirements, to NORTON COMPANY, 351 New Bond Street, Worcester 6, Mass.



*In Rockets, Jet Planes and Guided Missiles,* Norton products for reaction motors — ROKIDE "A" Aluminum Oxide Coating, ROKIDE "C" Silicon Carbide Coating and CRYSTOLON "N" Silicon Carbide Monolithic Bodies — are used for many applications.

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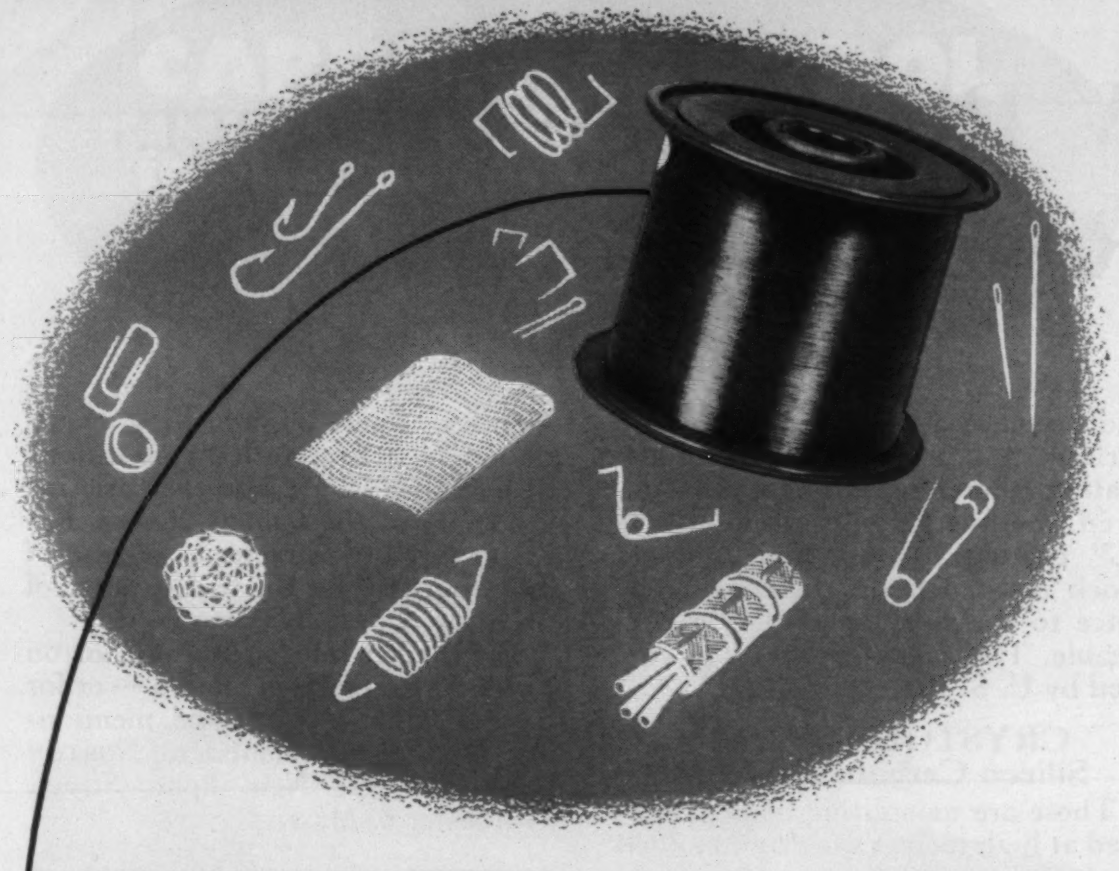

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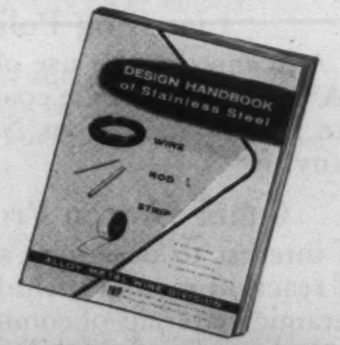

ALLOY METAL WIRE DIVISION

A DIVISION OF HKP H. K. PORTER COMPANY, INC.

H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

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## Contents Noted

reaction between metal and abrasive grain, and promotes fracture wear. With a grinding fluid, speeds between 1500 and 2500 sfpm are recommended. For dry grinding, speeds between 1000 and 1500 sfpm give good results. Low speeds also reduce the tendency for the sheet surface to be scorched or marred by accumulations of incandescent chips.

The author discusses various types of grinding fluids, and types of belts to be used with each. He points out that there is not much information available at present on economics of grinding titanium with coated abrasive belts on a production basis. However, he estimates that under good grinding conditions, each cubic inch of titanium metal removed will cost approximately 6 to 10 times as much as the equivalent amount of stainless steel. He points out that future improvements and developments will undoubtedly reduce grinding costs, and that even at present costs, abrasive belt grinding is giving excellent results at costs competitive with other methods of removing titanium stock.

### Rust in Cars

Almost all of the three million odd passenger cars scrapped each year are rusted beyond economic repair. Though the average life of cars scrapped in 1951 had increased to 13½ years, as compared with 6½ years for those scrapped in 1925, the increase was primarily the result of improved durability of engines and other mechanical parts.

In order to extend the service life of body structure to keep pace with mechanical improvements, considerable emphasis has been placed recently on improving design and protective coatings. However, in the past quarter century there has not been a significant improvement in corrosion resistance of auto body sheet steel. In a paper delivered before the Society of Automotive Engineers' Golden Anniversary Summer

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# Contents Noted

Meeting last June, J. C. Holzwarth, R. F. Thomson and A. L. Boegehold of G-M Research Labs described results of their work in investigating the nature of rust formation on auto-body sheet steel.

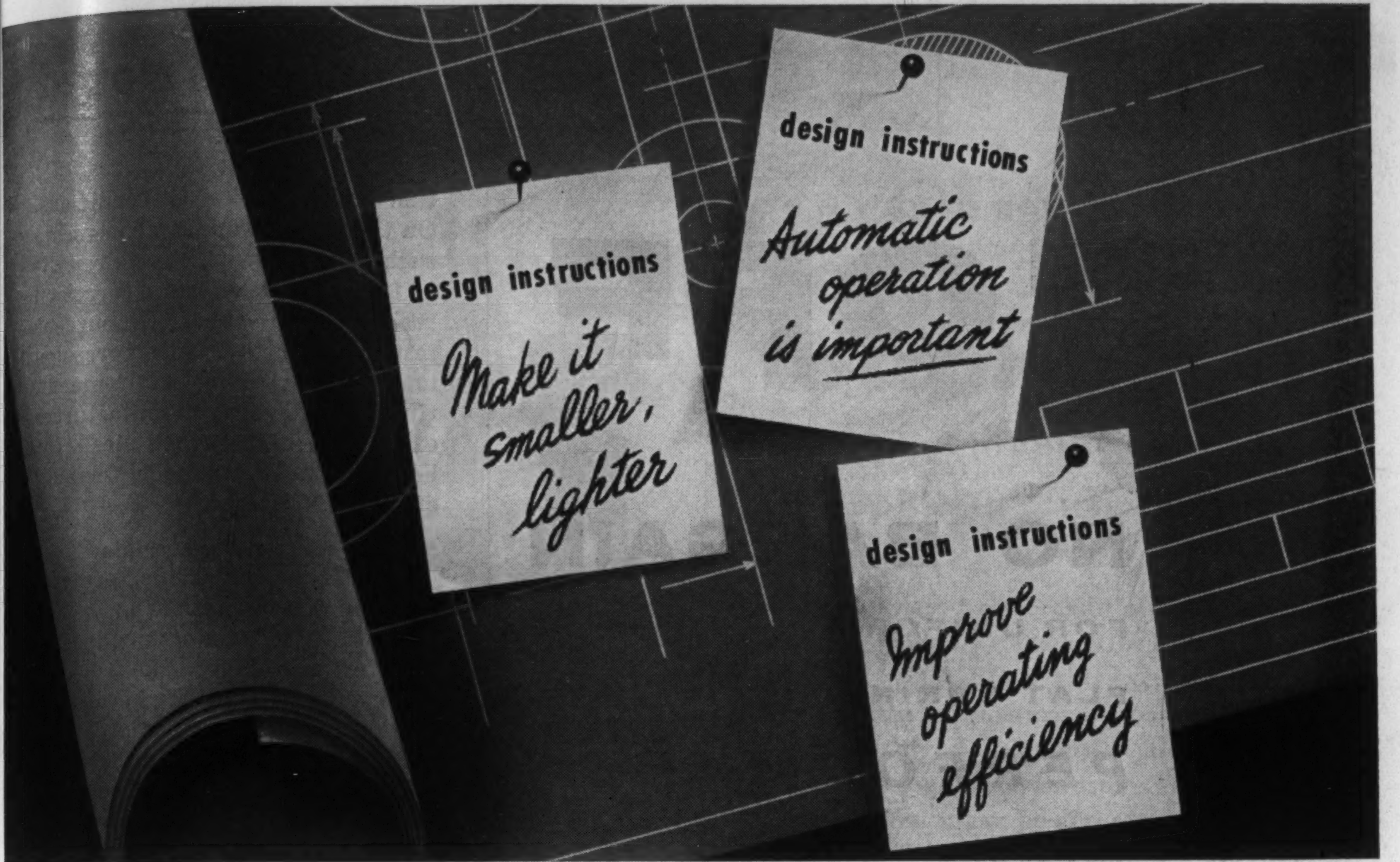
**Corrosion characteristics**

Corrosion of steel in car bodies is generally characterized by two types of rust: 1) rusting of exterior body surfaces where protective finishes have been worn or chipped away, and 2) rusting in sheltered areas where rapid deterioration and perforation of body parts takes place. The first, though a nuisance, can be readily controlled by polishing, waxing and touch-up painting. The second is insidious in that it occurs most often in inaccessible areas such as interiors of rocker panels, inside doors and window wells, or in crevices of the underbody. In these locations, rusting can proceed unnoticed until the affected parts are severely damaged.

The authors point out that previous work by several investigators has shown that sheltering action greatly accelerates corrosion by retarding the formation of protective rust. Washing action of rain aids protective rust formation by removing soluble corrosion products, which, if they remain in the rust, make it porous and permit further attack on the metal beneath.

Nonprotective rusts, produced in sheltered areas of car bodies, are composed of about 80-90% magnetite, and 10-20% $Fe_2O_3$ hydrates. On the other hand, protective rusts formed on low alloy steels exposed on outdoor test racks are essentially all $Fe_2O_3$ hydrates. Under the influence of sheltering action, rust formed outdoors may be nonprotective, occurring as porous rust containing high percentages of magnetite and small percentages of $Fe_2O_3$ hydrates.

Steel alloying elements which aid protective rust formation outdoors do not necessarily contribute to protective rust forma-



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Instrumentation . . . miniaturization . . . more automatic production . . . all are demanding parts and components with new operating advantages. And High Nickel Alloys are playing an important part in meeting the needs. Are *you* aware of the opportunities High Nickel Alloys offer? For example, do you know you can . . .

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## Contents Noted

tion under sheltered conditions. On the other hand, some elements such as carbon, which are reported to have little effect on corrosion resistance of steels in outdoor tests, appear to reduce corrosion under a sheltering environment. Unfortunately, car manufacturers cannot use high carbon steels for bodies due to its poor forming characteristics.

### Search for new materials

On various occasions, proprietary high strength, low alloy steels have been recommended for use in auto body construction. However, base price of these steels is 1½ times the cost of presently used rimmed steel. To date, no conclusive evidence has been presented to show that high strength, low alloy steels will increase corrosion durability sufficiently to justify this price increase. The goal, of course, is to develop a cheap, readily-formed sheet steel having markedly improved resistance to sheltered corrosion. A material which corrodes at about ¼ to ½ the rate of presently used auto body sheet would be satisfactory. Such an improvement would need to be accomplished without addition of large amounts of alloying elements which affect the forming characteristics and cost of the steel.

## Books . . .

**Tungsten.** *K. C. Li and Chung Yu Wang. Reinhold Publishing Corp., New York 22, N. Y. 1955. Cloth 6 by 9 in. 506 pp. Price $14.00.*

The third edition of this monograph has been thoroughly revised. Covered are the history, geology, ore dressing, metallurgy, chemistry, analysis, industrial applications and economics of tungsten. Many references are included to original sources.

This standard work on the subject will be a valuable addition to the library of the chemist, metallurgist or mining engineer working with tungsten, its compounds, or its alloys.

*(More Book Reviews on p. 206)*

# Here's a way to get real toughness in molded plastic components

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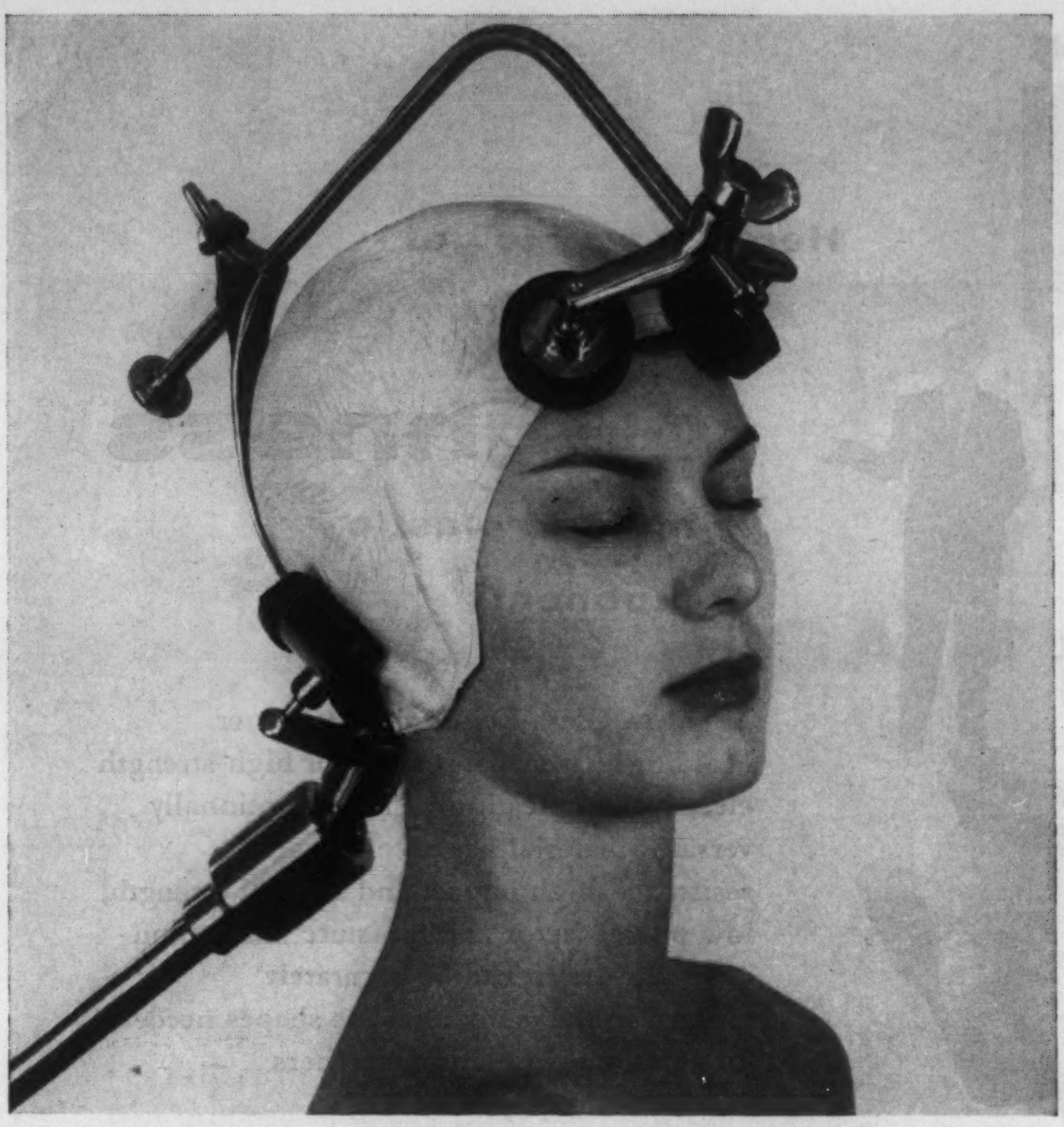

Photo courtesy American Sterilizer Co., Erie, Pa.

"Just What the Doctor Ordered"

**New Super-Soft Rubber Pads Developed for Surgical Table Headrest**

This surgical patient's head is in firm but gentle hands. The tight grip of the surgical table headrest shown above is now cushioned by super-soft (20 durometer) solid rubber pads. These pads are almost as soft as sponge but can be decontaminated and sterilized far more easily. Being made of neoprene, they are unaffected by oils, acids or decontaminating and sterilizing solutions. Furthermore, repeated sterilizing in live steam does not cause excessive hardening.

The neoprene compound specially developed for this purpose is 10 to 15 durometer points softer than normal commercial limits. For that reason, special care and skill must be taken in mixing and molding.

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# Contents Noted

## Books . . .

**Engineering Metallurgy.** *L. F. Mondolfo and Otto Zmeskal. McGraw-Hill Book Co., New York 36, N. Y. 1955. Cloth 6 by 9 in. 397 pp. Price $7.50.*

This text book is designed for engineering students whose primary interest does not lie in the metallurgical field. The emphasis is on the theory underlying various operations and several chapters are devoted to metallurgical theory as an introduction to practical applications.

This book is organized to give a general understanding of how and why metals perform as they do. Covered are theory of alloys, melting and casting operations, plastic working of metals, transformations in the solid state and their effects on the properties of alloys, heat treatment practice, welding, powder metallurgy, corrosion, and commercial metals. Suitable problems for class-room use are included.

**Die Design Handbook.** *Edited by Frank W. Wilson, American Society of Tool Engineers. McGraw-Hill Book Co., New York 36, N. Y. 1955. 768 pp. Price $14.50.*

This handbook was planned to provide die designers and users with details of hundreds of dies which have proved superior in cold metalpresswork applications. Die design is related also to other factors in pressroom processes. Thus material is included on product design factors, principles of process planning, theory of metal movement, die setting principles and selection of presses.

The handbook is the result of cooperative efforts of hundreds of members of the American Society of Tool Engineers and will prove a valuable addition to the working library of any engineer or designer concerned with pressworking operations.

**The New American Machinist's Handbook.** *Edited by Rupert LeGrand. McGraw-Hill Book Co., New York 36, N. Y. 1955. Cloth $5\frac{1}{2}$ by $8\frac{1}{2}$ in. 1572 pp. Price $11.00.*

This book is the successor to

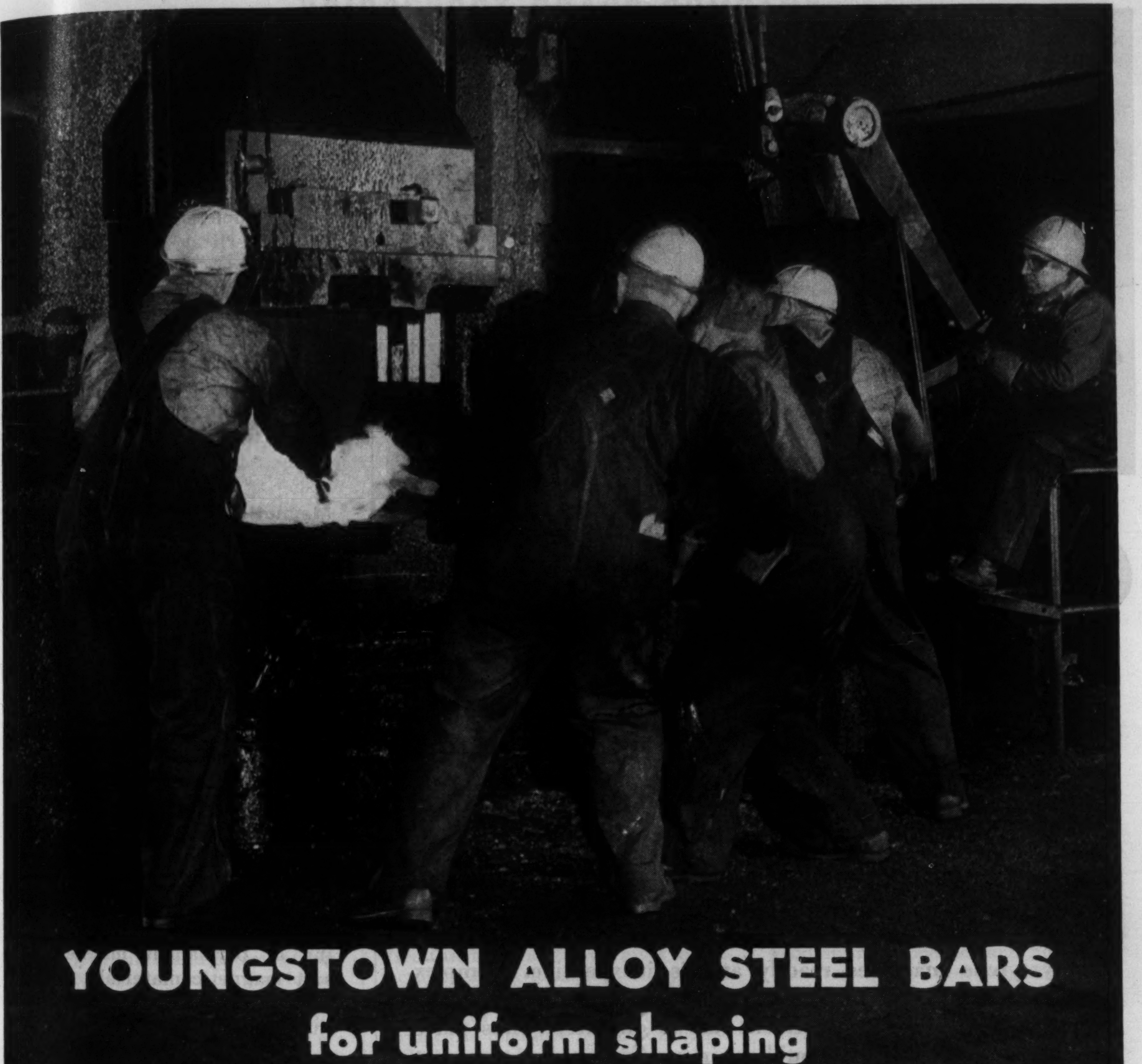

Photo courtesy Transue & Williams Steel Forging Corp.

●Quality control of Youngstown Hot Rolled Alloy Bars insures uniform chemical composition and mechanical properties, as well as uniformity of dimensions. These desirable characteristics result in minimum forging rejects and less loss in flashings.

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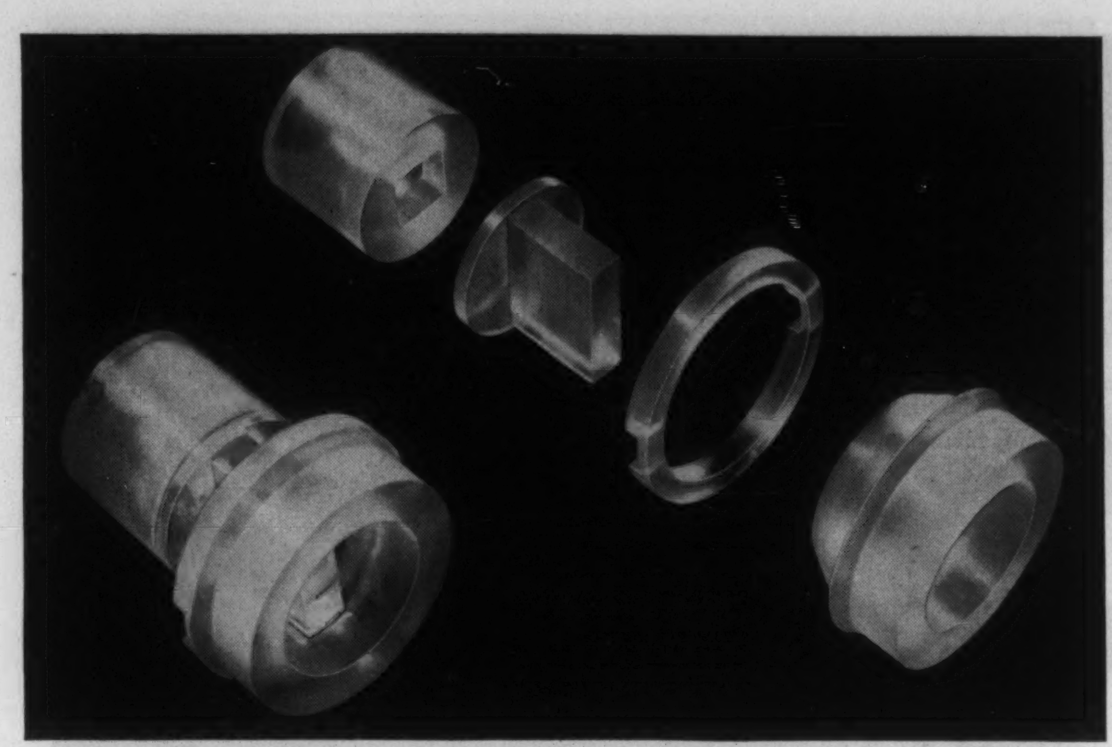

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Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

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# Contents Noted

## Books . . .

*American Machinist's Handbook*, editions of which were published for 45 years. The new book has been completely reorganized and 80% rewritten to provide up-to-date answers to practical problems in metalworking. The handbook contains information on machining, metal forming, assembly, drafting, inspection, fastening devices, tool engineering and drafting, machine tool standards, and power transmission. Many useful tables and formulas are included also.

**Magnetic Materials in the Electrical Industry.** *P. R. Bardell. Philosophical Library, Inc., New York 16, N. Y. 1955. Cloth 6 by 9 in. 288 pp. Price $10.00.*

This book is intended to bridge the gap between the academic study of the properties of magnetic materials and their practical applications. Written for the electrical engineer and industrial physicist, it discusses the large number of magnetic materials now available.

Chapters cover magnetic terminology, the influence of magnetic theory on the development of materials, application and testing of permanent magnets and soft magnetic materials. A glossary of terms and units is included.

## Reports . . .

**Aluminum tensile properties**

TENSILE PROPERTIES OF 7075-T6 AND 2024-T3 ALUMINUM-ALLOY SHEET HEATED AT UNIFORM TEMPERATURE RATES UNDER CONSTANT LOAD. *George J. Heimeri and John E. Inge. July 1955. 46 pp. diagrams, photos, tables. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington 25, D. C.*

NACA TN 3462

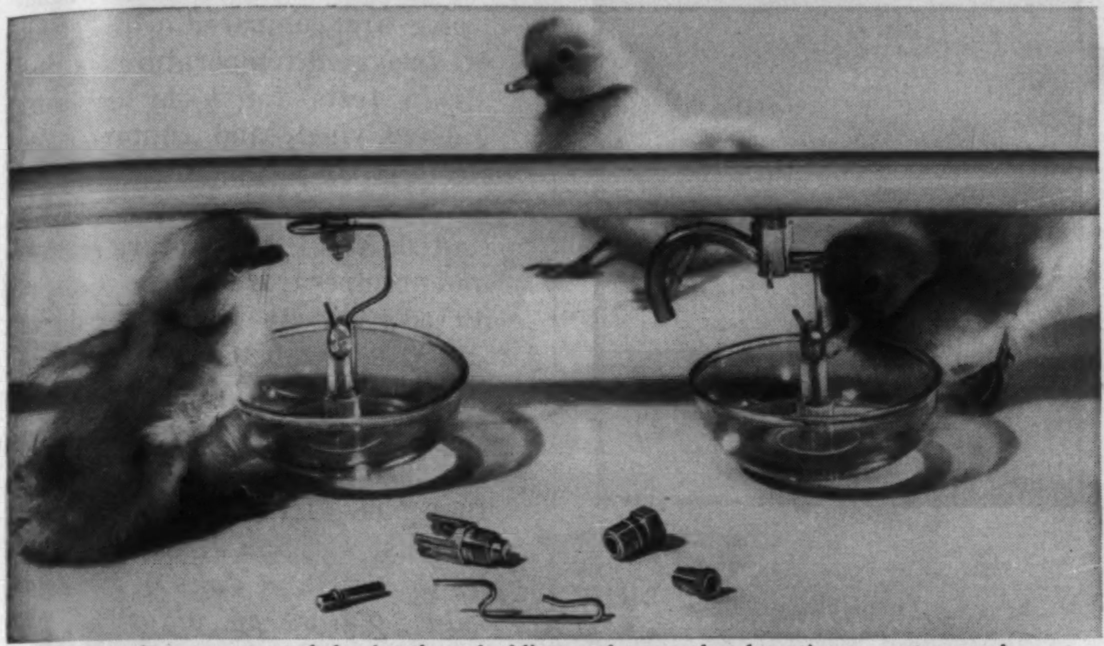
Results of tests to determine effect of heating at uniform temperature rates from 0.2 to 100 F per sec on the tensile properties of 7075-T6 (75S-T6) and 2024-T3

BRIDGEPORT BRASS COMPANY

# COPPER ALLOY BULLETIN

Bridgeport Brass Co.

Reporting new developments in copper-base alloys and metalworking methods.



Brass valve components help give these ducklings a clean, cool and continuous water supply.

## Automatic Drinking Fountains for Poultry Use Brass for Dependable Service

A good supply of clean, cool water helps to produce steady chick growth and good eggs, but the problem is to water poultry adequately without spillage, flooding, and, in the case of chicks, drowning.

A solution to this problem is the ingenious automatic drinking fountains made by Drinxall Manufacturing Company of North Hollywood, California.

With parts fabricated from Bridgeport copper-base alloys to Drinxall's own design, these poultry fountains are self-filling and sanitary. Poultry can't get in, nor water out, and chicks do their drinking right in pens, batteries or cages.

Drinking cups are suspended from water-supply lines by valves made from Bridgeport Free-Cutting Brass Rod Alloy 6 and by wire clips of Bridgeport Spring Brass Alloy 37. When water gets low in the plastic cups, a counterweight opens a supply valve until water reaches the proper drinking level, when the counterweight causes the valve to close.

Drinxall also uses Bridgeport copper-base alloys for a fountain using a peck-type valve, the valve opening when poultry peck at the moist valve stem.

The small, yet accurately made parts for the Drinxall valves shown are made from Bridgeport Free-Cutting Brass Rod Alloy 6. A composition of 61% copper and 3.4% lead gives this alloy exceptionally free-machining properties and a uniform composition. The use of Bridgeport Alloy 6 also assures accurate dimensions, essential in close-tolerance parts such as the small Drinxall valves shown above. Bridgeport Free-Cutting Rod Alloy 6 gives manufacturers a fast-production alloy ideal for high-speed, economical machining. Its strength and uniform composition serve close-tolerance requirements and make it particularly suitable for valves. Precision finishing assures efficient functioning, including perfect closing of metal-to-metal valve seats.

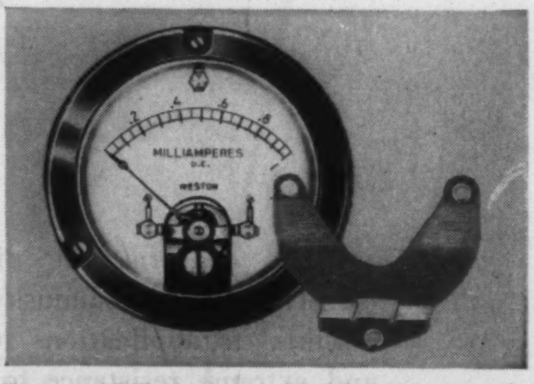
Bridgeport Copper Alloys were selected for Drinxall fountains because of their uniform high inner quality and consistent conformity with specifications covering composition, temper, finish and dimensions.

In thousands of cases such as this one, Bridgeport Technical Service representatives studied the requirements of an application, then recommended materials that have given satisfaction to manufacturers and customers alike.

Bridgeport Technical Service will recommend the alloys best suited to your particular applications, manufacturing methods, and production requirements. Call your local Bridgeport office for this helpful advice.

## Magnet Holders Stamped from BRIDGEPORT Nickel Silver Withstand Rugged Use, Meet High Standards

To insure that the ruggedized meters it manufactures are able to withstand hard use, Weston Electrical Instrument Corp., Newark, New Jersey, uses only the sturdiest of materials. In addition, these Weston instruments are tested on machines such as a 2,000 foot-pound shock-testing machine and various vibration-testing machines.



Weston Milli Ammeter Model 1521 uses the Nickel Silver Magnet Retainer inset at right.

A typical Weston part is the magnet retainer (shown above) stamped and formed from Bridgeport Nickel Silver Grade B 555. This alloy has high strength and corrosion resistance, plus good spring properties and high electrical resistance. These properties make Bridgeport Nickel Silver B 555 ideal for telephone boards, radio parts, electrical controls, optical goods, surgical and dental instruments, and diaphragms.

Weston's magnet holder is formed so that its base has a slight buckle which flattens when the holder is fastened to the instrument housing. Permanent spring action of Bridgeport Alloy B 555 secures the magnet holder.

In this application, as in others, the selection of suitable Bridgeport alloys was made after Bridgeport's technical service and laboratory experts studied the metalworking requirements of the manufacturer, then recommended the exact alloy, temper, finish and size—not only to meet specifications, but to assure product quality and sales acceptance.

Bridegport's helpful services . . . and 90 years of metalworking experience . . . are available to you through the nearest Bridgeport sales representative.

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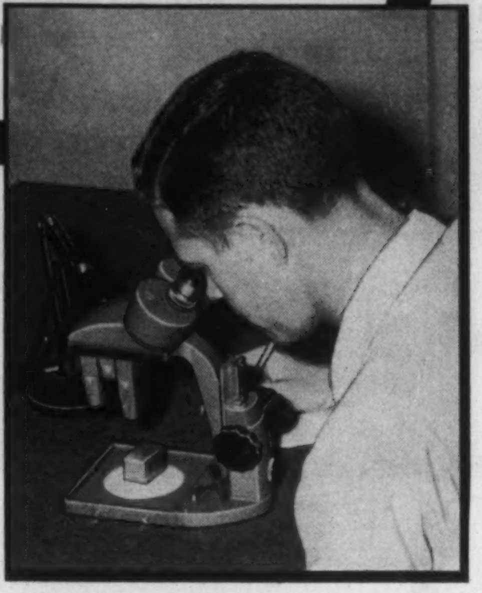

Many concerns are discovering strong uniform, closely grained Sandusky centrifugal castings are essential to applications requiring maximum strength and extreme resistance to heat, corrosion, and abrasion. Chief Sandusky continuous research is ever expanding the range of these uses.

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FERROUS AND NON-FERROUS
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## Contents Noted

### Reports . . .

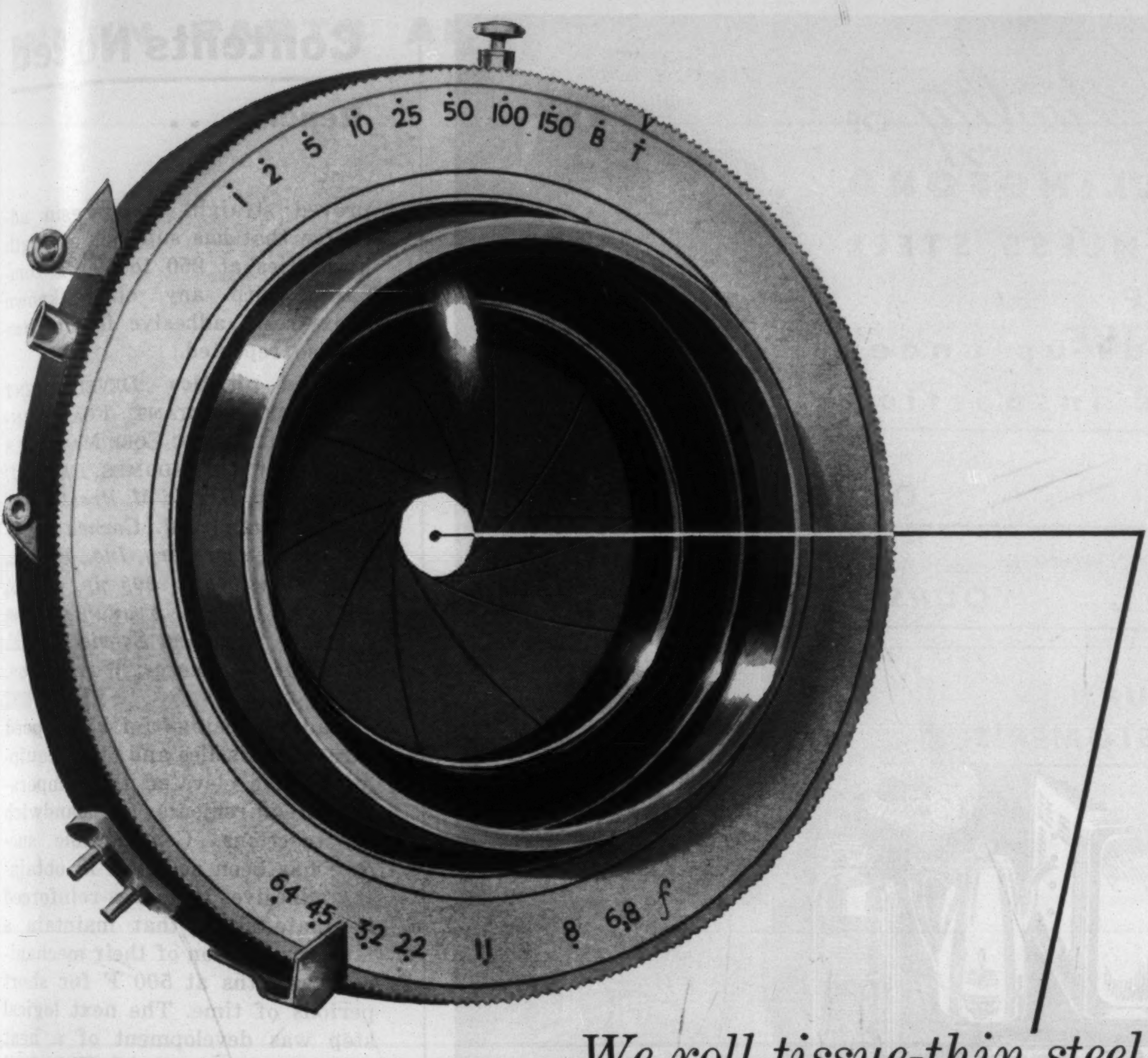
(24S-T3) aluminum-alloy sheet under constant-load conditions. Yield and rupture stresses, obtained under rapid-heating conditions, are compared with results of elevated-temperature stress-strain tests for ½-hr exposure. Master yield- and rupture-stress curves based on a linear temperature-rate parameter are presented. Yield and rupture stresses and temperatures may be predicted by means of master curves and the parameter.

**Heat treatment of HS-21 alloy** EFFECT OF SOME SELECTED HEAT TREATMENTS ON THE OPERATING LIFE OF CAST HS-21 TURBINE BLADES. *Francis J. Clauss, Floyd B. Garrett and John W. Weeton. July 1955. 39 pp. diagrams, photos. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N. W., Washington 25, D. C.* NACA TN 3512

Effects of heat treatment depend upon initial microstructure of cast blades. Blades from one manufacturer performed best in the as-cast condition; blades from a second manufacturer performed best after aging 48 hr at 1500 F. Solution treatments at 2050 F and above often caused damage by eutectic melting. Before the full benefits of heat treatment can be realized, casting conditions must be controlled to produce uniform structures with finely distributed carbides and a minimum of interdendritic segregation.

**Adhesive bonding** METAL-BONDING ADHESIVES FOR HIGH-TEMPERATURE SERVICE. *John M. Black and R. F. Blomquist, Forest Products Laboratory. July 1955. 22 pp. tables. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N. W., Washington 25, D. C.* NACA RM 55F08

Results of an investigation made for the purpose of developing a metal-bonding adhesive with improved heat-resistant properties are reported. The most promising results were obtained with a formulation of a phenol resin and an epoxy resin with certain heat stabilizers and catalysts. An im-



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# Contents Noted

## Reports . . .

proved straight epoxy-resin adhesive that has superior strength properties at 250 to 300 F compared with any other known epoxy-resin adhesive formulation is also reported.

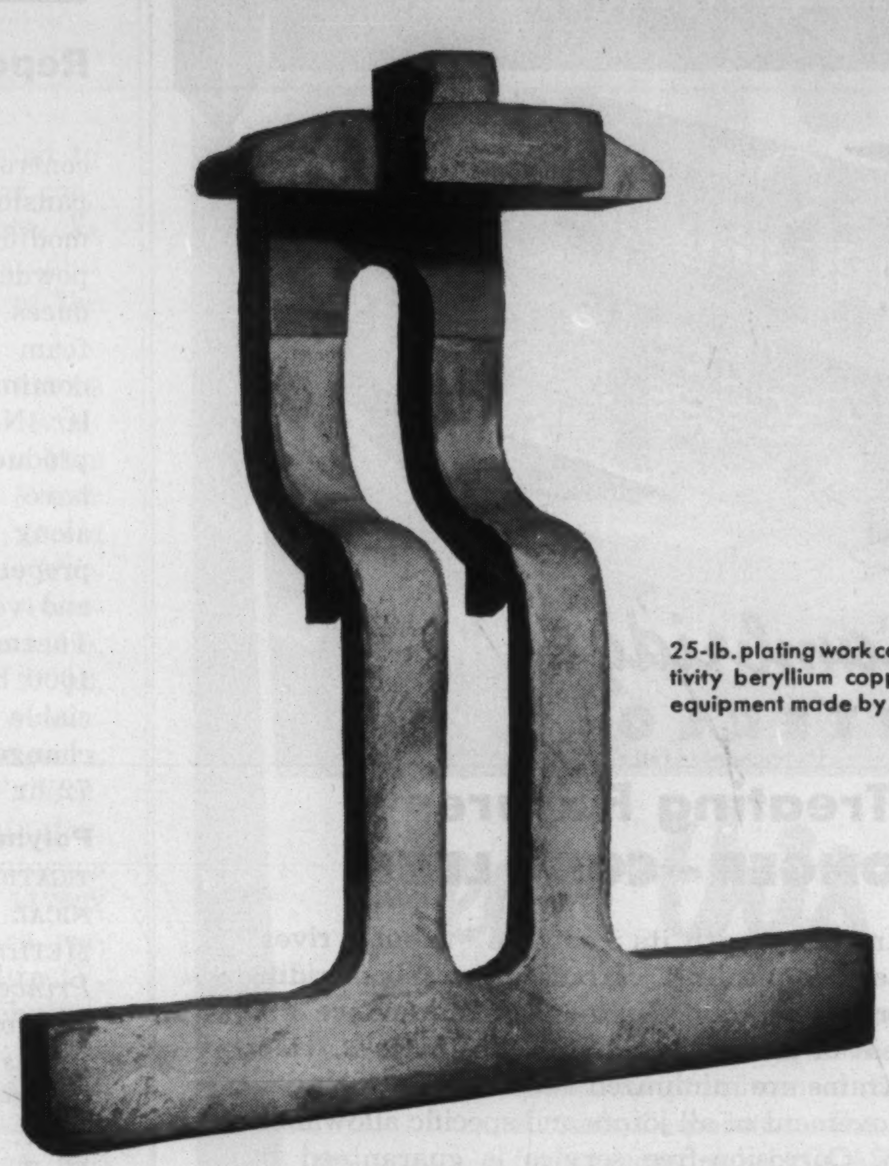
**Foamed plastics** DEVELOPMENT OF HEAT-RESISTANT FOAMED-IN-PLACE DIELECTRIC CORE MATERIALS FOR SANDWICH RADOMES. *Phillip J. Campagna, Harold M. Preston and Norman E. Wahl. Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y. Mar. 1954. 208 pp. photos, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $5.50.* PB 111692

Radar housings for high speed aircraft, missiles and other equipment have elevated the temperature requirements for sandwich constructions. Considerable success has been achieved in obtaining adhesives and glass-reinforced laminate skins that maintain a large proportion of their mechanical strengths at 500 F for short periods of time. The next logical step was development of a heat resistant core material. This final report summarizes work and accomplishments of this program. The report is divided into two parts; the first outlines target objectives of the study and presents results obtained; the second describes in detail materials investigated and the data obtained.

DEVELOPMENT OF A HEAT-RESISTANT FOAMED-IN-PLACE LOW-DENSITY SILICONE RESIN CORE MATERIAL. *Donald E. Weyer, James R. Russell and Kenneth R. Hoffman. Dow Corning Corp., Midland, Mich. Supplement Jan. 1955. 115 pp. photos, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $3.00.*
PB 111555s

The most promising method of producing foamed-in-place sandwich structures from silicone resins consists of expanding a dry powdered resin containing blowing agent, catalyst and inert filler. Core density can be conveniently

# WHEN PARTS ARE CAST FOR A TOUGH ROLE



25-lb. plating work carrier cast in high-conductivity beryllium copper and used in plating equipment made by The Udylite Corporation.

## THEY'RE MADE OF BERYLCO® BERYLLIUM COPPER

The increased amperage called for in modern plating equipment demands higher conductivity in this casting—a contact which rides on a copper bus bar and transmits current from the bar to the plating tanks. Various materials used in the past, although they had the required wear resistance, lacked the conductivity for this application. To get around the problem, engineers considered brazing a strip of high-conductivity "Berylco" beryllium copper to the part.

Our engineers recommended that instead the whole part be cast in "Berylco." The solution was ideal. "Berylco" not only combines high conductivity with high strength and remarkable wear resistance, but is also a very good casting alloy. Pouring temperatures are low, fluidity is excellent, and needed detail can be sharply reproduced. Most important, cost is competitive.

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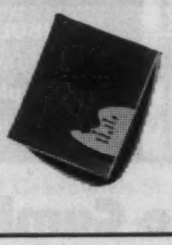

for "Berylco" beryllium copper are discussed in detail in this informative 32-page booklet. Send for your free copy today.

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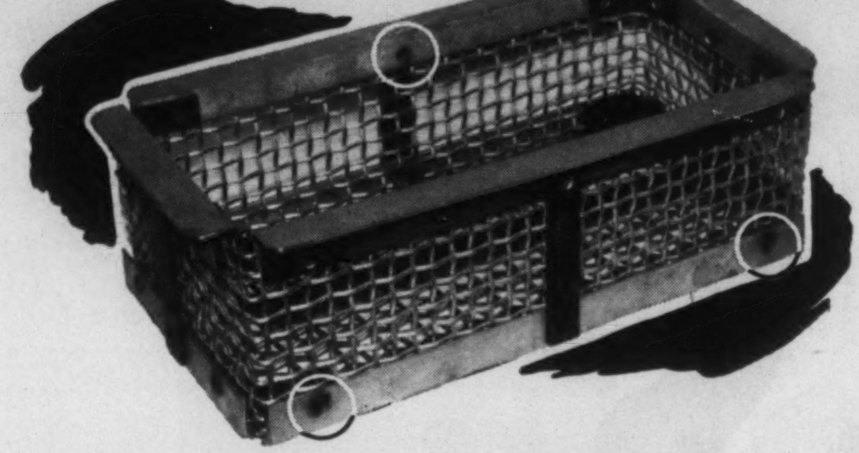

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Since we introduced Interlock with its exclusive "tubular rivet" construction, daily use in annealing, carburizing, carbonitriding has proven that Interlock all but eliminates maintenance and assures life far in excess of ordinary heat-treating fixtures. Heat treating stresses and strains are minimized because Interlock construction allows free movement of all joints and specific allowances for thermal expansion. Corrosion-free service is guaranteed by fabrication from metal or alloy to match process conditions. Here are a few reports we've received from leading manufacturers:

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✓ PROOF
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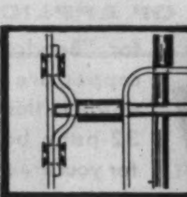
—Automobile manufacturer

✓ PROOF
"We've had no down-time since we started using Interlock."
—Machinery manufacturer



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## Contents Noted

### Reports . . .

controlled by adjustments in expansion temperature, and by small modifications in formulating the powder. Expansible powder produces a stable, uniform multipore foam with a pore structure predominately spherical and unicellular. None of the materials or byproducts are toxic. The foams have low moisture absorption along with excellent electrical properties. They are nonflammable and very resistant to open flame. Thermal life of the core was over 1000 hr at 600 F with no appreciable weight loss or dimensional change. Weight loss of core after 72 hr at 700 F was less than 6%.

**Polymethyl methacrylate** INVESTIGATION OF THE DYNAMIC MECHANICAL PROPERTIES OF POLYMETHYL METHACRYLATE. *Bryce Maxwell. Princeton University, Plastics Laboratory. Feb. 1955. 35 pp. diagrams, graphs. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $1.00.* PB 111642

**Magnetic ceramics** STUDY ON MAGNETIC CERAMICS. *George Economos. Massachusetts Institute of Technology, Laboratory for Insulation Research. May 1954. 61 pp. photos, drawings, diagrams, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $1.75.* PB 111625

Magnetite, manganese ferrite, and magnesium ferrite together with thirteen compositions within the system $Fe_2O_3$-MgO-MnO were investigated. A carbonate decomposition method of obtaining a well-dispersed oxide mix of high reactivity was used. The ferrites were also prepared and fired in various controlled atmospheres. Magnesium ferrite and one complex composition (approximate mole percent: 30 $Fe_2O_3$: 35 MgO: 35 MnO) with a rectangular hysteresis loop characteristic were investigated in detail under a variety of firing conditions. Changes in the magnetic properties of the complex ferrites in the center of the system $Fe_2O_3$-

## Contents Noted

### Reports . . .

MgO-MnO could be correlated to the amount and types of ions contributing magnetic moments. X-ray and microstructure studies aided in the interpretation of the experimental data.

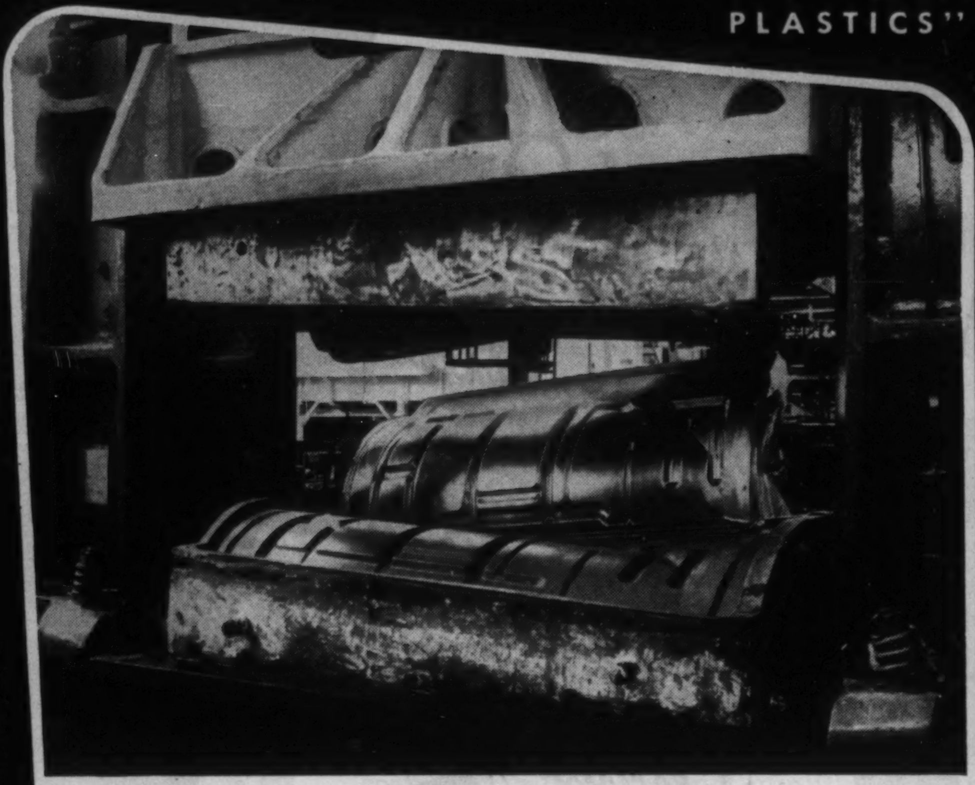
**Borides** CEMENTED BORIDES (PHYSICAL PROPERTIES), SUMMARY PROGRESS REPORT FROM MAY 1, 1953 TO JULY 31, 1954. *Frank W. Geaser, Michael G. Ford, David Moskowitz, William Ivanick, Norman Grossman and others. American Electro Metal Corporation, Yonkers, N. Y. July 1954. 27 pp. diagrams, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D. C. Microfilm $2.25, Photocopy $4.00.* PB 117522

A new high temperature material, designated as Borolite IV, has been developed, using chromium, molybdenum, and boron, which appears superior to most cermets in terms of heat resistance, resistance to oxidation, and stress to rupture strength. Work is in progress to improve its resistance to impact.

**Brazing aluminum** INVESTIGATION OF BRAZING OF ALUMINUM ALLOY PARTS. *J. G. Ballingall. U. S. Naval Air Material Center, Aeronautical Materials Laboratory, Naval Air Experimental Station, Philadelphia, Pa. May 1950. 15 pp. photos, tables. Available from Library of Congress, Photoduplication Service, Publication Board Project, Washington, D. C. $2.75.* PB 117716

This report presents the results of (a) a study to secure information from the literature on the subject of brazing aluminum alloys, (b) tests to determine the applicability of the process to aircraft construction and repair, and (c) a determination of the tests necessary for specification requirements to control and evaluate the quality of brazed joints.

**Vacuum and salt bath brazing** PRELIMINARY INVESTIGATION OF PROPERTIES OF HIGH-TEMPERATURE BRAZED JOINTS PROCESSED IN VAC-



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*An outstanding development of great significance* in the use of synthetic resins for tooling is this new drop-hammer die at the Lockheed Aircraft Corporation. The high impact die facing material is EPOCAST*, developed by FURANE Plastics based on CIBA Araldite Epoxy Resins. It is hard enough to form most gages of aluminum and thinner stainless steels. In addition to exceptional mechanical efficiency, the EPOCAST facing material economically eliminates die-grinding and spotting that is needed when conventional tools are used. Worth looking into . . . as are *all* CIBA-base plastics. *Trade Name

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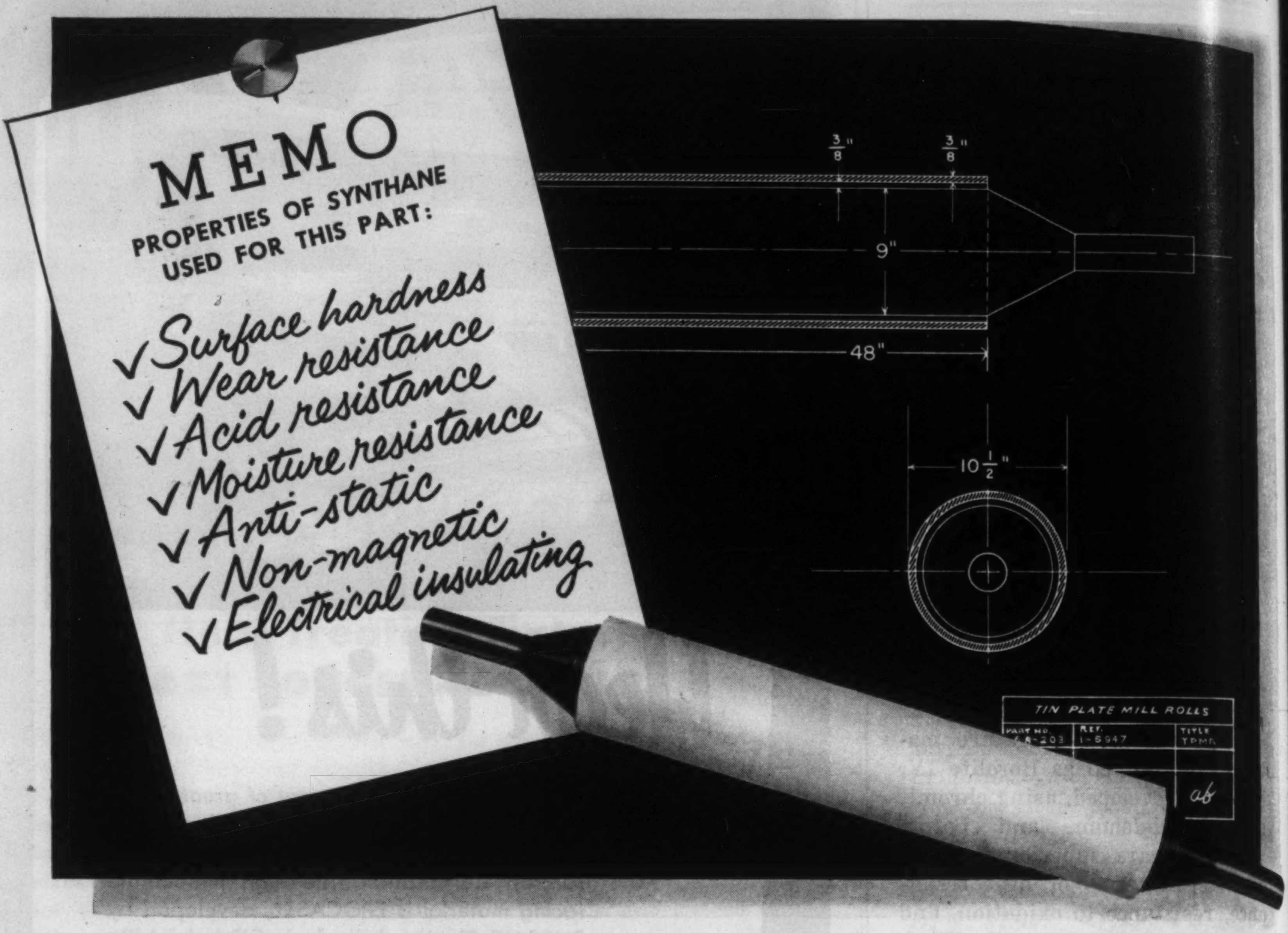
MEMO
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✓ Acid resistance
✓ Moisture resistance
✓ Anti-static
✓ Non-magnetic
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9"
48"
10 1/2"
TIN PLATE MILL ROLLS
PART NO.
REF.
TITLE

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The net result is a 3 to 5 times longer life for Synthane-covered rolls, far less downtime; less maintenance and higher production rates. Look into Synthane's combination of properties for your product or application. Write for booklet of Synthane sheets, rods, tubes and fabricating service.

**SYNTHANE**
LAMINATED PLASTICS

**SYNTHANE CORPORATION • OAKS, PENNSYLVANIA**

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## Contents Noted

### Reports . . .

UUM OR IN MOLTEN SALT. *C. A. Gyorgak and A. C. Francisco. U. S. National Advisory Committee for Aeronautics. May 1955. 29 pp. photos, drawings, tables. Order from National Advisory Committee for Aeronautics, 1512 "H" St., N. W., Washington 25, D. C.* PB 117394

An investigation was conducted to determine the effect of the variables temperature, time at temperature, and nickel addition to the braze alloy on the shear strength of high-temperature-alloy brazed joints processed in vacuum or in molten salt. Both brazing methods produced shear strength greater than those of joints processed in dry hydrogen. Vacuum brazing was superior to salt-bath brazing, average shear strengths being on the order of 63,000 and 48,000 psi, respectively.

**High temperature rubbers** DEVELOPMENT OF HIGH-TEMPERATURE OIL-RESISTANT RUBBER. *William H. Gillen, William J. Mueller, Richard A. Clark, Randall G. Heiligmann. Battelle Memorial Institute, Columbus, Ohio. Jan. 1955. 134 pp. drawing, diagrams, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington, D. C. $3.50.* PB 111693

This project has been set up with two objectives. The first is the development of a rubber composition which will withstand MIL-L-7808 lubricants for at least 500 hr at 350 F. The second objective is the development of a rubber which will withstand ester-type hydraulic fluids at 400 to 550 F. Minimum target properties for these compounds are given in Appendix A.

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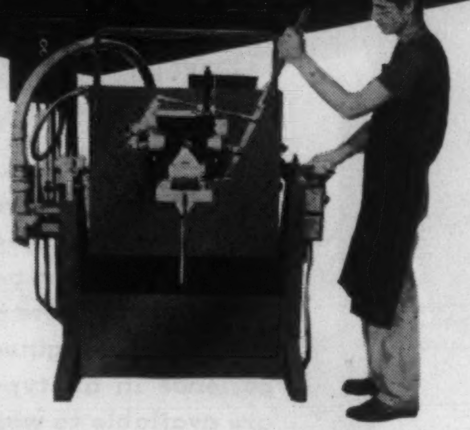

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## news of ENGINEERS COMPANIES SOCIETIES

### NEWS OF ENGINEERS

**Herman Plone** has been appointed chief engineer, Aircraft Standards, Inc.

**J. Bremner Proctor** has been made general manager of Alan Wood Steel Co.'s new Penco Metal Products Div.

**Robert B. Battersby,** formerly chief engineer of the Thermosetting Div., Auburn Button Works, Inc., has been advanced to the position of manager of that division.

**Roger B. Knowles** has been named general manager of the Reinforced Plastics Div., Bigelow-Sanford Carpet Co.

**Dr. Joseph J. Eachus** has been selected as systems director and **J. Ernest Smith** as director of engineering for Datamatic Corp., a newly-formed firm owned jointly by Minneapolis-Honeywell Regulator Co. and Raytheon Manufacturing Co.

**Robert A. Lannoye, John F. Langkau, Roger Gilbert, Jr., Bruce M. Lane, Eugene F. Riebling** and **Neal Griffing** have recently joined the staff of Electro Metallurgical Co.'s Metals Research Laboratories.

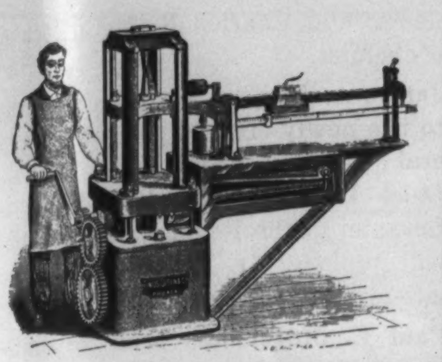
**C. S. Wiedman** has been given the new post of manager of carbide products development engineering, Carboloy Department, General Electric Co.

**Sheldon G. Little** has been designated as assistant chief engineer, GMC Truck & Coach Div., General Motors Corp.

**Howard J. Peppercorn** has been promoted to works manager of The General Tire & Rubber Co.'s Marion, Ind., plant, and **Lester A. Kaye** has been named works manager of the company's Logansport plant in Indiana.

**Delbert W. Rosenbaum** has joined the staff of The B. F. Goodrich Co. Research Center as a technical man. Other appointments to the staff of the center include **George Pescan** as a technical man in the physics department, **Manuel Esayian** as a member of the technical services group, **G. Robert Moore, Ray V. Mihailovich** and **Robert F. Singer** as junior technical men, **Dwight M. Wever** and **Robert J. Minchak** as chemical engi-

TINIUS OLSEN



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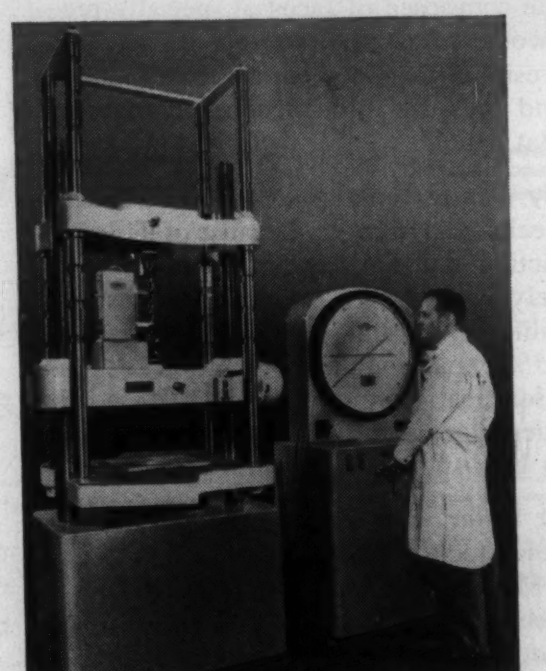

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HOW CAN YOU USE VERSATILE NEW NOVOPLY?

**Nothing like Novoply.** Novoply is a 3-ply laminate composed of faces of specially prepared wood flakes and a core of wood chips — all resin-impregnated, and molded under heat and pressure into an extremely dense, hard, flat panel.

**Novoply plus features.** Novoply has tremendous mechanical strength. Because of its 3-ply construction and high water-resistance it is extremely flat and warp-resistant. Dimensional stability is unusual in *all* directions—*less than 0.3%* expansion and contraction even in the presence of extreme humidity. It's good *both* sides, glues readily, and works easily on modern high-speed equipment.

**Make it better with Novoply.** Some current uses: core stock for high pressure laminates such as Micarta®, store fixture cabinets, cores for veneered furniture, practically warp-free sliding doors, wall paneling, counter fronts. Get your free sample and data book and see what Novoply suggests to you.

**1.** Novoply surface is remarkably flat, and its mosaic-textured look makes it a handsome panel for decorative use. **2.** Top and bottom surface plies are precision-made wood flakes. **3.** Center ply is of specially graded wood chips. Both flakes and chips are resin-coated and -impregnated.

**NOVOPLY PANEL SPECIFICATIONS: THICKNESS:** ¾"; **SIZES:** 24" x 72", 24" x 96", 30" x 48", 30" x 60", 30" x 72", 36" x 72", 48" x 48", 48" x 72", 48" x 84", 48" x 96", 48" x 120", 48" x 144"; also cut-to-size for volume users from panels 6' x 12' and 4' x 16'. Available in ⅜", ⅝", 11/16", 1" thicknesses, sizes 48" x 96", and other sizes. **IMPORTANT NOTE:** Only slight extra cost for long-length Novoply panels up to 16'.

**NOVOPLY®**
**by Weldwood®**
*A product of*
**United States Plywood Corporation**
*World's Largest Plywood Organization*
87 Distributing Units in Principal Cities

**UNITED STATES PLYWOOD CORPORATION**
**Weldwood Building**
**55 West 44th Street, New York 36, N. Y.**

**RUSH** my free sample of Novoply, and engineering data booklet detailing results of Novoply tests conducted by a famous independent research and testing laboratory.
M-10-5

NAME........................................................
COMPANY....................................................
ADDRESS....................................................
CITY.......................STATE............

For more information, turn to Reader Service Card, Circle No. 453

neers, and **Charles R. McCulloch** as a chemist.

**James A. Johnson** has been advanced to the newly-created position of general superintendent, The Indiana Steel Products Co. **Darrell Davis**, foreman in the Foundry Department, will replace Mr. Johnson as superintendent of that department.

**Paul C. Meyer** has been appointed assistant to the vice president and general manager of Kaiser Engineers Div., Henry J. Kaiser Co. **C. H. Case** has been made a division manager for the same division of the company.

**A. K. Brill** has retired from his position as development manager of Republic Rubber Div., Lee Rubber & Tire Corp. **J. P. Mathews** has been promoted to chief chemist for the company and will assume the duties formerly handled by Mr. Brill.

**George Cagen** has been selected as chief product engineer, The Lux Clock Manufacturing Co. Mr. Cagen heads a new department devoted to developing new products and adapting present Lux timing devices to broader application in the original equipment field.

**J. Nall Candler** has been made vice president and plant manager of Morse Chain Co.'s Detroit plant to succeed **M. V. Durkin,** who has retired.

**Gerald C. Rich** has been named manager of the Microwave Tube Laboratory, Sylvania Electric Products, Inc.

**Charles F. Sawyer** has been designated works manager of the Latrobe Mill, Vanadium-Alloys Steel Co.

**Dr. John C. Lee** has been appointed chief engineer of the Industrial Div., The Wayne Pump Co.

**H. J. Buttner** has been made manager of engineering for the Le Roi Div., Westinghouse Air Brake Co.

**Douglas B. Fraser** has been named manager of the recently-purchased Cincinnati plant of ALCO Products, Inc.

**G. H. Cole,** formerly associate director of research, Armco Steel Corp., has been made consulting engineer for magnetic materials in the company's research laboratories. **V. W. Carpenter** will succeed Cole and will direct Armco's future research work in the field of magnetic materials. In addition, **D. C. Dieterly** has been appointed supervisor of Armco's magnetic research laboratory.

*(More News on p. 224)*

# Looking for a TOUGHER STEEL?

## Unusually tough, even at sub-zero temperatures, Lukens "T-1" steel can reduce equipment costs.

Failure from abrasion or from impact can happen to the steel in your equipment, too. Here's the answer—the tougher steel you've been looking for. Lukens "T-1" steel has excellent resistance to the combination of wear and impact, is tough enough to withstand unusual stresses and pressures as well as shock at either sub-zero or high temperatures, thus lowering maintenance costs and lengthening equipment life.

Because of its high yield strength (over 90,000 psi) this new, all-purpose steel offers lighter weight and reduced thickness in comparison to heavier, thicker plates of carbon steel, thereby reducing material, construction and shipping costs. Engineers and designers can take advantage of Lukens "T-1" steel's many superior properties, such as its ready weldability and excellent wear characteristics, which will pay off in design freedom and increased equipment efficiency. And Lukens' range of steel plate sizes—including the widest and heaviest plates available anywhere—makes possible additional savings through the use of wider plates that require fewer welded seams.

The latest addition to Lukens' complete line of carbon, alloy and clad steels, this quenched and tempered alloy plate steel's unusual combination of properties suit it especially to application in pressure vessels, bridges, shipbuilding, construction machinery and general industrial equipment. On problems of design, selection, application and fabricating techniques, Lukens offers full technical assistance. If you would like further information on Lukens "T-1" steel, write for the new 28-page Bulletin 781. Address: Manager, Marketing Service, 776 Lukens Building, Lukens Steel Company, Coatesville, Pa.

**LUKENS "T-1" STEEL**

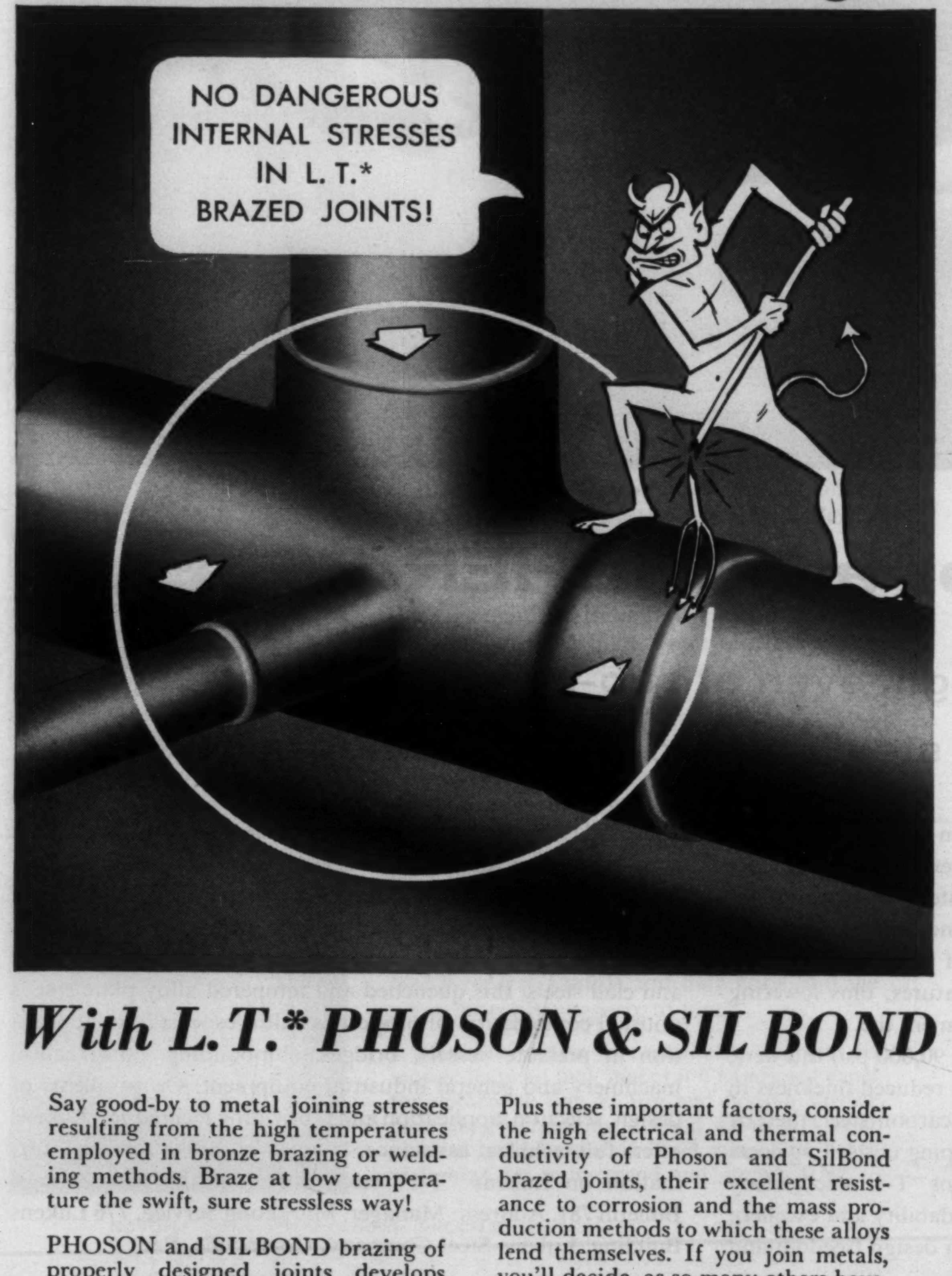
**THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS**

**LUKENS STEEL COMPANY, COATESVILLE, PENNSYLVANIA**

**For more information, turn to Reader Service Card, Circle No. 425**

Joining Metals?

Then BRAZE Them For "No-Stress" Joining!


NO DANGEROUS INTERNAL STRESSES IN L. T.* BRAZED JOINTS!

With L. T.* PHOSON & SIL BOND

Say good-by to metal joining stresses resulting from the high temperatures employed in bronze brazing or welding methods. Braze at low temperature the swift, sure stressless way!

PHOSON and SIL BOND brazing of properly designed joints develops strength equal, or greater than the strength of the metals joined . . . not possible with soft solders. There are no extra finishing costs, no dangerous, unrelieved stresses which often result in welding techniques. There is no threading as in joining by fasteners, with attendant loss of strength.

Plus these important factors, consider the high electrical and thermal conductivity of Phoson and SilBond brazed joints, their excellent resistance to corrosion and the mass production methods to which these alloys lend themselves. If you join metals, you'll decide, as so many others have, to braze with Phoson and SilBond.

Ask for the PHOSON — SIL BOND Booklet.

*Low Temperature

UNITED WIRE & SUPPLY CORPORATION
Brazing Alloy Division • Providence 7, R. I.
Offices in Principal Cities • Coast-to-Coast

*Contact your Welding Supply Distributor*

UNITED *LOW TEMPERATURE* BRAZING ALLOYS *Permanently United*

For more information, turn to Reader Service Card, Circle No. 505

## news of | ENGINEERS

**Roy C. Heacock** has been appointed director of engineering, Axelson Manufacturing Co., Div. of U. S. Industries, Inc.

**John Cameron** has been named assistant chief engineer, Hamilton Mechanical Presses, of the Hamilton Div., Baldwin-Lima-Hamilton Corp.

**Martin G. Gale** has been selected as director of technical service for the Monomer Department of The Borden Co.'s Chemical Div.

**Dr. David B. Parkinson** and **John H. Harris** have been promoted to vice presidents, Brush Electronics Co. Mr. Harris will be vice president and general works manager, and Dr. Parkinson will be vice president and general engineering manager.

**Hubert B. Smith** has been appointed director of product engineering at the Claymont, Del., plant of The Colorado Fuel and Iron Corp.

**Dr. Robert M. Brick**, formerly director of the School of Metallurgical Engineering, University of Pennsylvania, has been named director of the Department of Metallurgy of Continental Can Co.'s Central Research and Engineering Div.

**Ervin Seltzer** has been transferred to the headquarters of The Electric Storage Battery Co.'s Exide Industrial Div. and appointed to manager of industrial engineering.

**Steven Galagan** has been made director of engineering for The Gabriel Laboratories and the Gabriel Electronics Div., The Gabriel Co.

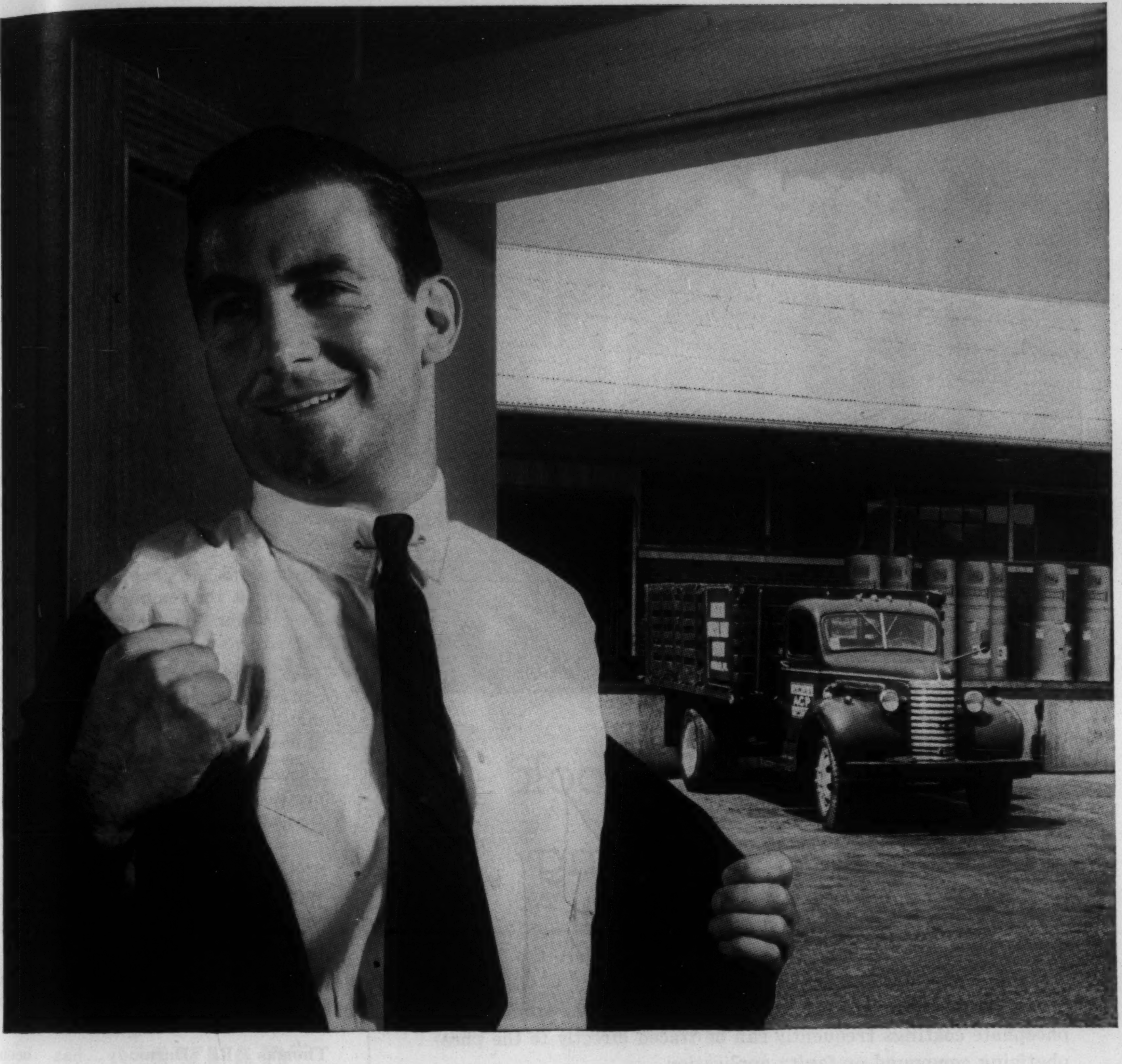
**Angus J. O'Brien** has been advanced to the newly-created position of vice-president and director of engineering and manufacturing, Gar Wood Industries, Inc.

**W. D. Kleppinger**, formerly general manager of the Chemical Equipment Div., General Ceramics Corp., has been elected vice-president of that division.

**Dwight C. Brown** has been transferred to supervisor, Chemical Engineering Services, a new section in the Technical Services Div., Research & Development Department, Jones & Laughlin Steel Corp. **D. J. Shellenberger, J. J. Butler, Jr.,** and **J. K. McCauley, Jr.,** all of whom recently joined J&L, have been assigned to the new section under Mr. Brown.

**Dr. Paul W. Bachman** has been elected vice president and director of research and development, Koppers Co., Inc.

*(More News on p. 226)*



## WE DON'T STOP WITH THE DELIVERY OF A CHEMICAL—

## we put it to work and keep it working effectively

The chemical treatment of metals and metal parts—to prepare them for further processing, to protect them, to beautify them—has grown from a haphazard operation to a highly technical one. Supplying the chemical ingredients is a relatively simple job. Putting them to work and keeping them working effectively in your plant demands the skill of an experienced organization. We have that organization.

We supply not only the metal-treating chemicals, but also—free of charge—the technical and engineering service to keep them working at top efficiency. We furnish assistance in developing and installing the process, we maintain continuing inspection of the process and equipment if you so desire, we check samples of the processed metals in our Quality Control Laboratories—all these are part of the ACP service at your command.

That's why we say, "We don't stop with the delivery of a chemical—we put it to work and keep it working effectively." And we have been doing this for over 40 years. Write for a booklet describing ACP products and services.

**AMERICAN CHEMICAL PAINT COMPANY, Ambler 15, Pa.**

**DETROIT, MICHIGAN** **NILES, CALIFORNIA** **WINDSOR, ONTARIO**

CHEMICALS
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PROCESSES

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(*Advertisement*)

A Customer's Look at Phosphatizing

How many times have we heard remarks like these . . . "The finish is brittle and tends to chip from the base", or "Once the finish is fractured, the metal is rapidly corroded." The key to those complaints is generally the phosphate coating. And the trouble with phosphate coatings frequently can be traced directly to the phosphatizing compound or faulty application.

The most outstanding phosphatizing compound on the market today is called Divobond. Microscopic examination reveals that Divobond produces a thin, tightly adherent mono-molecular coating bringing paint closer to the base metal thus assuring a secure finish-to-metal bond. Since the coating is amorphous and completely devoid of crystals, it does not tend to crack when the finish is broken. Also, this inert, uniform iron phosphate Divobond coating protects the metal from rapid corrosion once the organic film is fractured.

Divobond has successfully proven its ability to increase the attractiveness and sales appeal of products produced by some of America's leading manufacturers. In addition, production personnel have found Divobond solves several difficult manufacturing problems. For example, it cleans and phosphatizes in one operation; it minimizes down-time by preventing scale on spray nozzles and buildup on heating coils; it works faster, allowing stepped-up production; and non-critical pH permits simplified control.

For further information on Divobond write to: The Diversey Corporation, 1820 Roscoe Street, Chicago 13, Illinois.

For more information, turn to Reader Service Card, Circle No. 385

**Noel V. Wood, Jr.**, has assumed the duties of process engineering supervisor for Mobay Chemical Co.

**Dr. Clarence E. Larson** has been named vice-president in charge of research, National Carbon Co. Dr. Larson was formerly director of the Oak Ridge National Laboratory, operated by Union Carbide and Carbon Corp. for the Atomic Energy Commission.

**W. H. Crowley** has been designated as chief engineer in charge of all engineering activities, including production, development, research and vacuum systems and equipment, for the Kinney Manufacturing Div., The New York Air Brake Co.

**Richard S. G. Schmidt** has been added to the engineering staff of The Parker Appliance Co. as a rubber engineer.

**John E. Unger** has been selected as administrative assistant to the manager of manufacturing for the Home Appliance Div., Servel, Inc.

**Theodore Gela**, formerly assistant professor of metallurgy at Stevens Institute of Technology, has been promoted to the rank of associate professor.

**William E. Hibbard** has joined Superweld Corp. in the new position of application engineer.

**John Rundt** has been made chief engineer, Development and Research Div., The Timken Roller Bearing Co.

**Thomas R. Darmody** has been named assistant general manager of Vitro Engineering Div., Vitro Corp. of America.

## news of | COMPANIES

**Alloy Rods Co.** has formally opened its new research and development center adjacent to its general offices and plant at York, Pa.

**American-Marietta Co.** has launched an expansion program involving approximately ten million dollars. The program provides for construction of additional facilities at several locations where demand for the company's products has exceeded productive capacity, and for the immediate acquisition of a sizeable company to further broaden American-Marietta's operations.

**AMF Atomics, Inc.**, a subsidiary of American Machine & Foundry Co.,

# MYLAR* gives Comptometer® a recording belt guaranteed for life!

# MYLAR* offers you almost unlimited possibilities for developing new products . . . improving old ones

An outstanding feature of the new Comptometer® Dictation Machine shown above is the magnetic recording belt made with Du Pont "Mylar" polyester film. The manufacturer, Felt & Tarrant Mfg. Co., Chicago, Illinois, reports that the high strength of this amazing film makes possible an unconditional lifetime guarantee for its Erase-O-Matic belt—against wear, tear, heat, moisture and cold.

This successful product innovation is only one example of the way an imaginative industry is putting the unique potentials of Du Pont "Mylar" to profitable use. From metallic yarns to smaller transformers for guided missiles, Du Pont "Mylar" is making possible better products and lower costs in a wide variety of fields. Here's why:

"Mylar" has a tensile strength of 25,000 pounds per square inch, about one-third that of machine steel. It has a greater dielectric strength than almost any known insulating material, and an impact strength at least twice that of any known commercial film. What's more, Du Pont "Mylar" is resistant to moisture and solvents, and remains flexible and stable over a temperature range extending from -80°F. to 300°F.

Just a little creative research may show you where this versatile film can be used to *your* advantage. Mail coupon for a fact-filled booklet that tells you more about Du Pont "Mylar"—and the ways it may help you improve a product.

*"Mylar" is the registered Du Pont trademark for its brand of polyester film.

**DU PONT**

**MYLAR®**

**POLYESTER FILM**

DU PONT
REG. U. S. PAT. OFF.

**Better Things for Better Living . . . *through Chemistry***

E. I. du Pont de Nemours & Co. (Inc.)
Film Department, Room 10-T, Nemours Bldg.
Wilmington 98, Del.

Please send me sample and further information on "Mylar" polyester film.

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Firm__________________________

Street Address____________________

City________________State________

**For more information, turn to Reader Service Card, Circle No. 460**

How REVERE saves money, metal and time with

SPERRY REFLECTOSCOPES

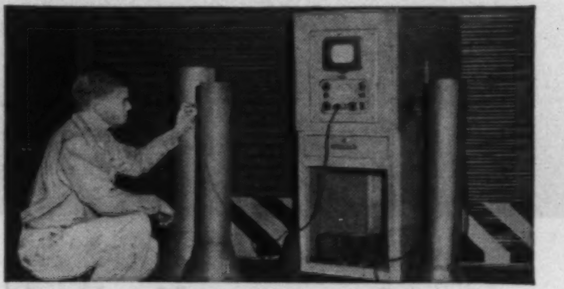
*Operator probes 8-in. diameter, 7- to 8-ft. round aluminum ingots from end and along axis for flaws. Test is simple, fast and accurate; keeps step with high-speed production; saves metal, money and time.*

**Line casting aluminum ingots** is a high-speed operation at the Baltimore plant of Revere Copper and Brass. Fast testing for flaws in castings is vital to their quality control.

**The old testing method** – cutting, machining and etching discs – put a big time lag between casting and defect detection.

**The new testing method** – probing ingots ultrasonically with a Sperry Reflectoscope – cuts that time lag tremendously. Performed immediately after casting and cooling, test shows defects instantly. Casting procedure can be promptly altered. Ingot defects are pin-pointed and cut out – only sound metal passes.

Revere also uses Reflectoscopes for production maintenance – checking hydraulic extrusion rams, tie rods, bolts, stems and other highly stressed parts for fatigue cracks – insuring against equipment breakdowns. Thus, Revere gets double-barreled savings from Sperry Reflectoscopes.



*Sperry offers America's most complete line of ultrasonic testing equipment for practical industrial applications.* Ask your Sperry representative for full information and a working demonstration in your plant . . . or write or call us today.

*First in practical ultrasonic testing for more than a decade.*

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4010 Shelter Rock Road
Danbury, Connecticut

☐ Please send me a copy of your new Bulletin 50-105.

☐ Have your representative call.

Material to be tested..............................
Name..............................
Title..............................
Company..............................
Address..............................
City.............................. Zone.......... State..........

☐ *Please tell me how to arrange for free showing of 10-minute color film explaining the theory and application of ultrasonic testing.*

For more information, turn to Reader Service Card, Circle No. 474

has announced that it has joined seven other companies in plans to construct and operate a nuclear reactor in the New York area for research in industrial and humanitarian fields. Construction of the Industrial Reactor Laboratories, as the facility will be called, is scheduled to begin this fall and is expected to be ready for use in about one year. Other companies participating in the formulation of plans include **American Tobacco Co., Continental** Can Co., **Corning Glass Works, The** International **Nickel Co., Inc., Chas.** Pfizer **& Co., Inc., Socony Mobil** Oil Co., **Inc.,** and **United States Rubber** Co.

**Ferro Corp.** has announced plans for a new $350,000 engineering facility to be located adjacent to Ferro headquarters in Cleveland. The two-story structure will house the Ferro Engineering Div. and the Allied Engineering Div.

**Firth Sterling, Inc.** has acquired a half interest in a newly-formed company, **Strategic Metals Corp.,** with facilities located at Conshohocken, Pa. This plant is engaged in the chemical beneficiation of complex tungsten ores and residues into suitable feed material for Firth Sterling's ammonium paratungstate plant in Trafford, Pa.

**The Garrett Corp.**'s Air Cruisers Div. has been appointed by **B. F. Goodrich Co.** to fabricate Vulcafilm products. Vulcafilm is a new, specially formulated, man-made acrylonitride butadiene rubber designed for simple fabrication of large rubber articles, especially those requiring an oilproof, high strength construction.

**The Goodyear Tire & Rubber Co.** has made plans for a substantial expansion of its synthetic rubber producing facilities at Houston, Texas. The plant will be enlarged in two stages which will ultimately provide a 50% increase in capacity.

**Hexcel Products, Inc.** has installed new production facilities capable of increasing by five times the company's present output of aluminum honeycomb sandwich material.

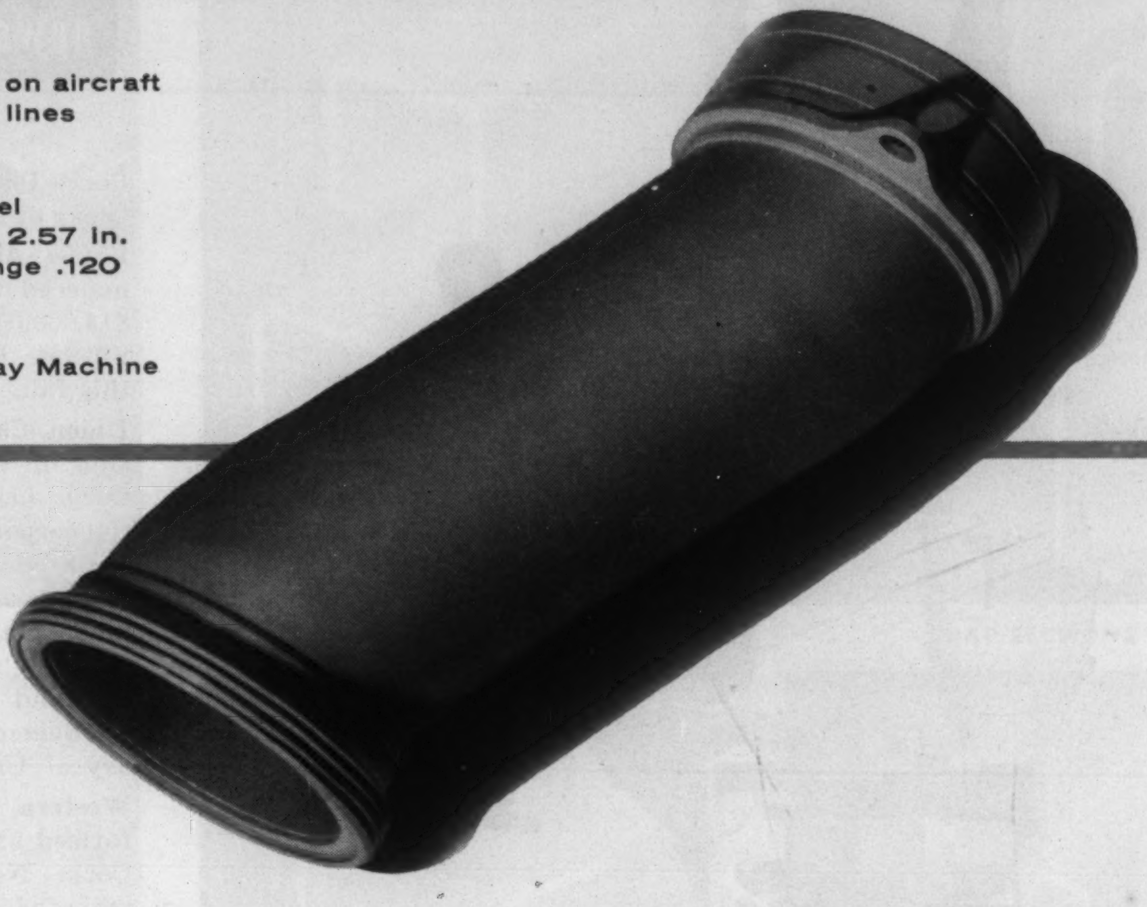
**Holiday Plastics, Inc.** has acquired **Thermacote Plastic Products Corp.**

**L•O•F Glass Fibers Co.** has begun construction of a plant facility in Defiance, Ohio. The new plant will be known as Defiance Plant No. 2 and will be used for storing insulation products manufactured at De-

**PRODUCT:**
Brazed joints on aircraft
engine intake lines

**MATERIAL:**
Stainless Steel
.090 Tubing, 2.57 in.
diameter, flange .120

**EQUIPMENT:**
250 k. v. X-ray Machine



# What's the right X-ray film?

## ☑ Kodak Industrial X-ray Film, Type M

Heat and vibration give a tough time to the brazed joints on intake lines of aircraft engines. So for the safety of airmen and planes, each joint is radiographed.

For the x-ray job, the radiographer uses 200 k.v. for 1 min. at 60 in., a filter cassette and Kodak Industrial X-ray Film, Type M.

This type film provides the best characteristics to meet this particular combination of radiographic factors.

**RADIOGRAPHY...**
***another important example of photography at work***

### THERE'S A RIGHT FILM FOR EVERY PROBLEM

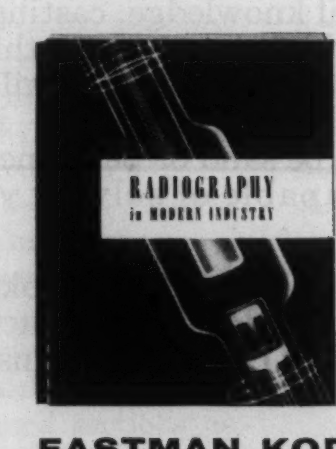
Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

**Type M**—provides maximum radiographic sensitivity with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

**Type A**—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage—heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

**Type F**—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

**Type K**—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.



### RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

**EASTMAN KODAK COMPANY**
**X-ray Division**
**Rochester 4, N.Y.**

Kodak

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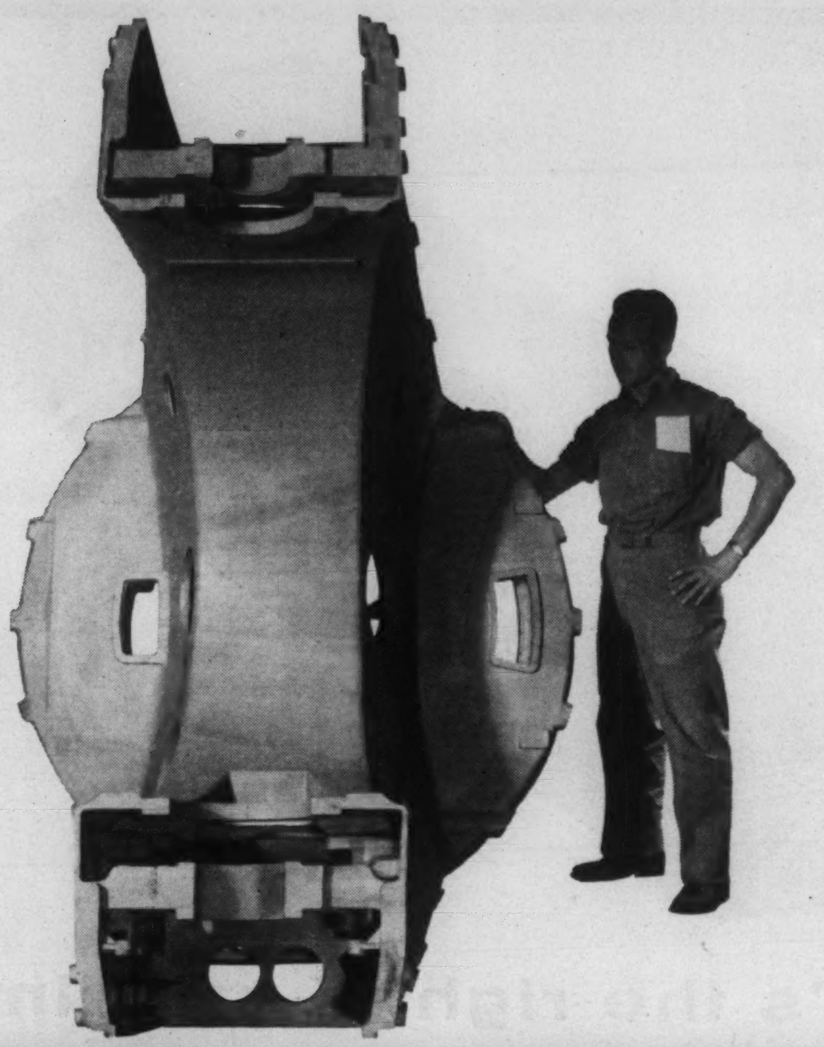


**the story of this casting cannot be told**

We *can* say that this 620 lb. magnesium yoke is part of a military electronic equipment structure. But no more! It was once seriously doubted that this part *could* be cast. The methods used to solve the problem are the result of Rolle's years of specialization.

The same metallurgical knowledge, casting experience, and foundry facilities which have made this and other equally complex castings possible are available to you. Whether they are commercial or military—in aluminum or magnesium alloys—to be sand or permanent mold cast—you will find Rolle capable of solving your casting problems.

Write now for your copy of a free booklet on Rolle complete foundry service to Rolle Manufacturing Company, 303 Cannon Avenue, Lansdale, Pennsylvania.

fight weight with strength with ROLLE
MANUFACTURING COMPANY
303 Cannon Avenue Lansdale, Penna.

For more information, turn to Reader Service Card, Circle No. 426

## news of | COMPANIES

fiance Plant No. 1, as well as various types of light fabrication.

**Linde Air Products Co.** has announced that production at its new $14,000,000 Long Reach (W. Va.) Silicone Plant is scheduled to begin this fall.

**Union Carbide Nuclear Co.**, a division of **Union Carbide and Carbon Corp.**, has been formed to integrate the corporation's diverse activities in the atomic energy field. In addition, Union Carbide and Carbon Corp. has made plans to build a polyethylene plastics plant near Grangemouth, Scotland. The plant will be operated by **Gemec Chemicals Co.**, a subsidiary of **Union Carbide Ltd.**

**Western Carbide Corp.** has been formed as a subsidiary of **Superweld Corp.**, North Hollywood, Calif., to manufacture and market proprietary products. The new corporation is making a hardfacing paste and several hardfacing bulk products.

**C. H. Wheeler Manufacturing Co.** has taken over the **Cruse-Kemper Co.** plant at Ambler, Pa. The latter company will be operated as the Cruse-Kemper Div. of C. H. Wheeler.

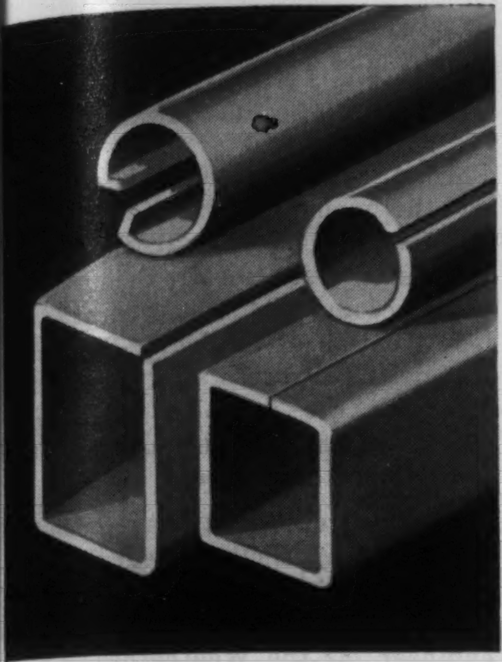
## news of | SOCIETIES

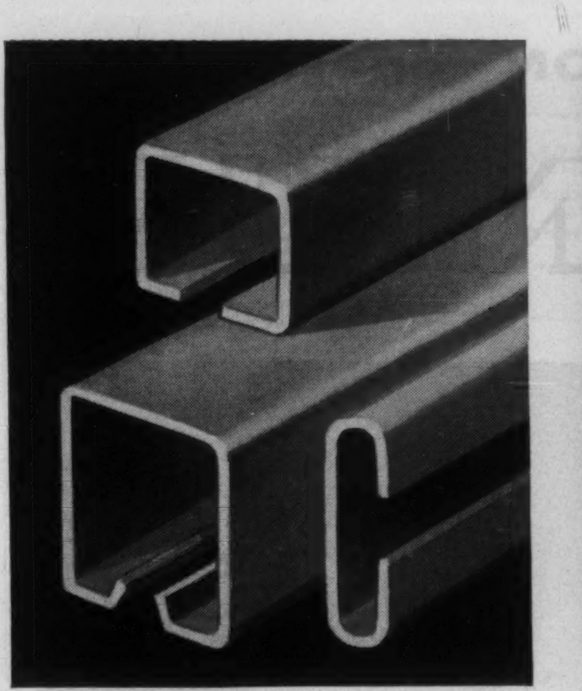
The **American Die Casting Institute**, at its recent annual meeting in Chicago, presented the Annual Doehler Award to Charles Pack, former vice-president of the Doehler-Jarvis Div., National Lead Co. Mr. Pack was cited for his 44 years of pioneering effort in the die casting industry.

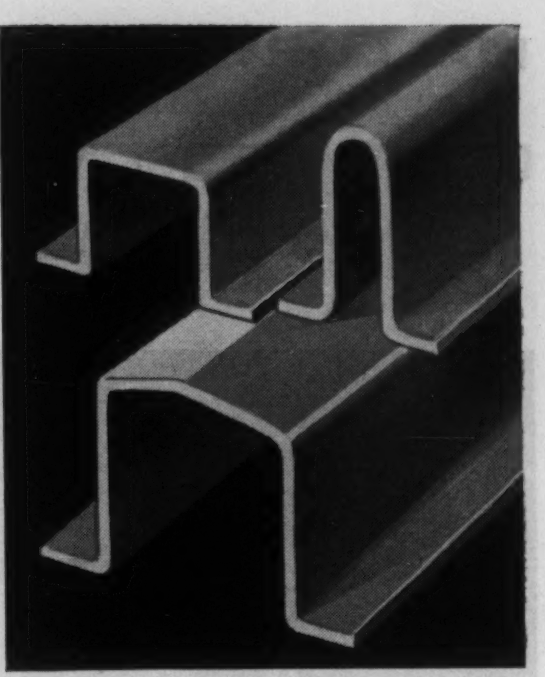
In addition, the Institute re-elected all of its officers from president through the board of directors. William J. During, president, Precision Castings Co., was re-elected president for the 1956 term. George Ralls, president, Pressure Castings, Inc., was re-elected vice-president. David Laine and W. J. Parker, both of the American Die Casting Institute, were re-elected secretary and treasurer, respectively.

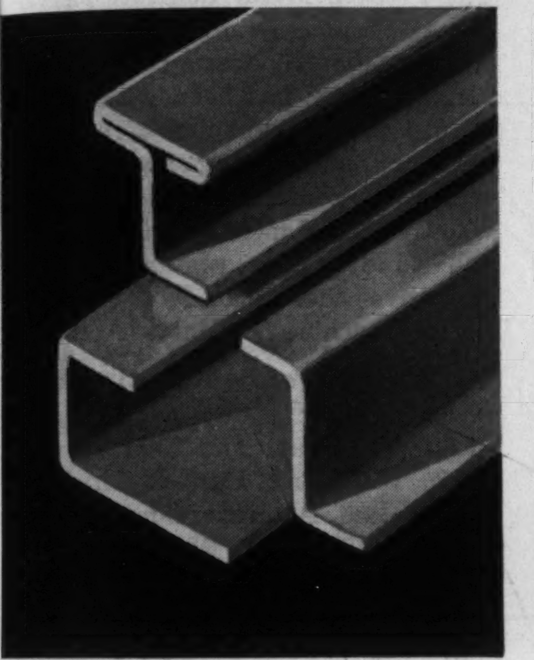
The **Franklin Institute** has announced that Jacques Yves Pierre Sejournet, managing director, Comptoir Industriel d'Etirage & Profilage de Metaux, Persan, France, will be one of the 1955 recipients of the Institute's John Price Wetherill Medal.

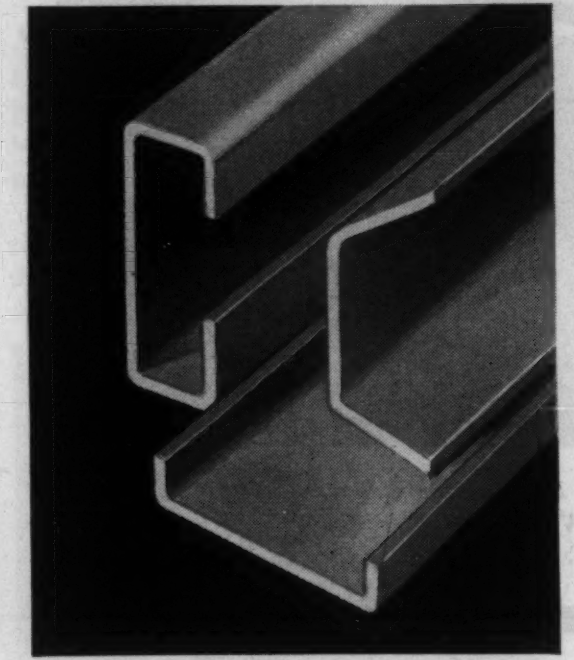
*(Continued on p. 232)*

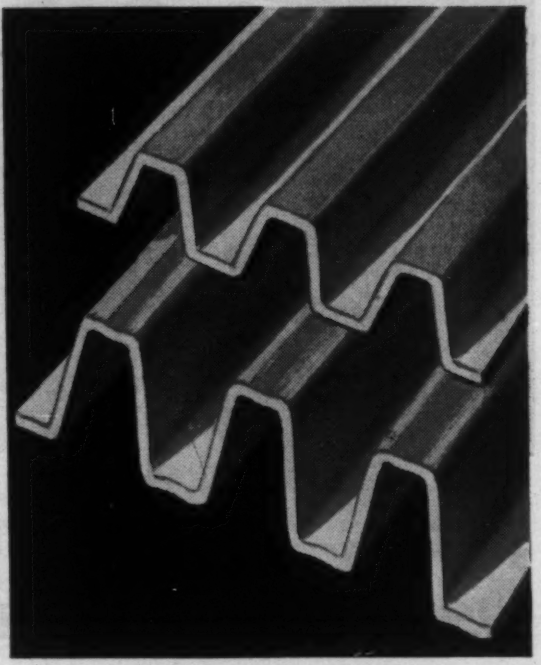

TUBULAR SECTIONS


TRACK SECTIONS


HAT SECTIONS


TEES AND ANGLES


CHANNEL SECTIONS


SPECIAL SECTIONS

# Each of these Shapes saved time and money for some manufacturer

Each one of the Bethlehem Cold-Formed Shapes we show here has saved some manufacturer both shop time and money. The sections shown were chosen from many hundreds to give you an idea of the range and versatility of Bethlehem Cold-Formed Shapes. There is almost no limit to their application in a wide variety of industries, including agriculture, transportation, manufacturing of all types, and materials-handling.

Bethlehem Cold-Formed Shapes save time because they are made to the customer's dimensions, to fit a particular job, with no need for cutting, bending or punching. Sections made from cold-rolled, or pickled and oiled steel are free from scale, ready for painting or welding without further preparation.

Bethlehem Cold-Formed Shapes save money because in many cases a lighter section can be used in place of heavier, hot-rolled material. There's no need to maintain large plant inventories, for Bethlehem will make and ship Cold-Formed sections as they are needed. No problem of scrap disposal, either.

Chances are that one of the shapes you see here—or a modification of it—could be adapted to your own product. Our engineers will be glad to study your needs and give you suggestions. We make a full range of shapes, in any gage from 5 to 24, of sheet, strip or plate steel, in almost any length. Your inquiry addressed to the nearest Bethlehem sales office will receive prompt attention.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

**BETHLEHEM STEEL**

BETHLEHEM STEEL

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MALLORY·SHARON reports on

TITANIUM

*Forgings of MST titanium alloy before and after finish machining.*

**NOW! Titanium forgings strengthen the SKYRAY'S sting**

- These forgings made of a Mallory-Sharon titanium alloy signal another major step for the metal that's making news every day.

The Douglas Skyray, world's fastest carrier-based aircraft, uses the parts for bomb ejector breeches . . . one of the first applications of titanium forgings in airframe structures. The parts are made from Mallory-Sharon's MST 3Al-5Cr, strongest titanium-base alloy in production, since the breeches must withstand corrosion and severe stresses from exploding gases.

Titanium saves weight, adds strength, resists corrosion. If these properties can help *you* make a better product, use the experience of Mallory-Sharon, leading producer of titanium and titanium alloys.

Write or call Mallory-Sharon Titanium Corporation, Niles, Ohio.

MALLORY Ti SHARON

For more information, turn to Reader Service Card, Circle No. 508

## news of | SOCIETIES

Formal presentation of the medal will be made at The Franklin Institute's Annual Medal Day ceremonies on Oct. 19. Mr. Sejournet is being recognized "in consideration of his invention of the Ugine-Sejournet Extrusion Process for metals—stressing the ingenious utilization of glass as a lubricant and the effective method of its uses."

The **Gray Iron Society** has appointed E. Harold Mitchell as field director. Prior to his appointment to the GIFS staff, Mr. Mitchell was sales engineer for the Weatherhead Co.

The **Pressed Metal Institute** has announced the appointment of Harold A. Daschner as managing director. Mr. Daschner has been with the Institute in the capacity of assistant manager and acting managing director. He replaces Orrin B. Werntz, who retired Jan. 1, 1955, to spend full time in his regular work as executive vice president, National Screw Machine Products Assn.

The **Society of Automotive Engineers** recently announced that John M. Tyler, Pratt and Whitney Aircraft Div., and Edward C. Perry, Jr., United Aircraft Corp., will be awarded the SAE's Manly Memorial Medal for 1954 at the Society's Golden Anniversary Aeronautic Meeting, Oct. 13. The Manly Award honors "the author of the best paper relating to the theory or practice in the design or construction of, or research on, aeronautic powerplants or their parts or accessories, which shall have been presented at a meeting of the SAE." Tyler and Perry's paper, "Jet Noise," was presented at the SAE 1954 Aeronautic Meeting in New York.

*(Meetings & Expositions on p. 234)*

Now

U.S. DEFENSE BONDS

EVEN BETTER

CORNING GLASS

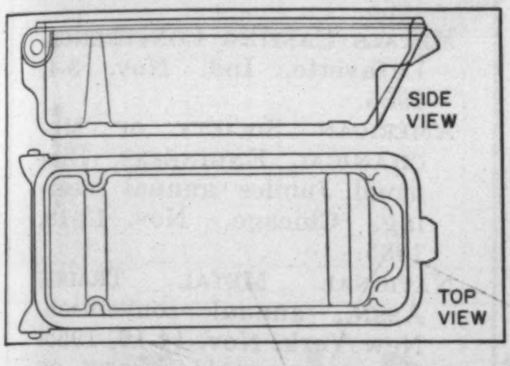
# BULLETIN FOR PRODUCT DESIGNERS

**CORNING GLASS WORKS, 12-10 Crystal Street, Corning, New York**
Please send me the material checked below:
☐ B-83: "Properties of Selected Commercial Glassware." ☐ B-84: "Manufacture and Design of Commercial Glassware." ☐ Booklet: "Glass and You."
Name__________
Title__________
Company__________
Address__________
City__________ Zone______ State______

### *Bold mold*

It has come to our attention that often simplicity embraces complexity.

A good case in point: the dental tray you see pictured. It's a relatively simple outfit for sterilizing small instruments by immersion. A product of the Bard-Parker Co., it's made of a PYREX brand glass, metal, and rubber.



Our contribution to the working simplicity of this sterilizer is the glass body. Actually, this main component is a quite complex, one-piece object, *molded* of one of our most versatile glasses, PYREX brand No. 7740.

A close look at the illustration will give you some idea of the many angles, radii, ridges and such to be calculated in making the molds in which this tray is pressed. Yet, its precise tolerances allow the metal and rubber cover to fit and hinge on the glass lugs, and the inside metal tray rests evenly on the built-in glass supports for draining.

At the risk of repetition, we mention again that all this is *molded* in one piece of glass.

Which brings us to the point that under Corning's scrutiny, glass can be readily made in shapes and for purposes that may never have occurred to you as possible with so hard, durable, and seemingly inflexible a material.

(And the fact that this item is made of a PYREX brand glass and stands up to the chemical action of the antiseptic solution should not be overlooked.)

From this bold mold you can induce that glass, economically mass produced by any one of a variety of processes, may hold the answer to some ticklish design and/or production problem of yours.

For nothing more than postage you might start finding out with a booklet called: "B-84—Manufacture and Design of Commercial Glassware." It tells about blowing, pressing, multiforming, sealing, assembling glass to metal, and other factors of interest to men of practical turn. Check the coupon for your copy.

### *Making light of it*

Campers, world travelers and those deprived of electrical illumination have long turned to portable Coleman lanterns for light.

Pressurized gasoline is burned in a thorium mantle. These light sources give off with some 300 candle power, about what you get from a 300-watt bulb.

To achieve such an output, the mantle reaches and holds at about 3,000° F.

Problem: What kind of glass chimney will stand up near this internal heat, the differential ambient temperatures, and the rugged handling such a portable light is bound to get?

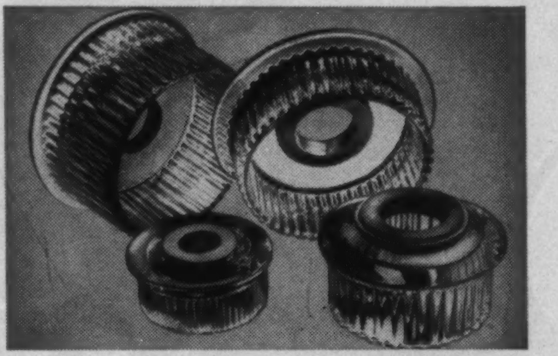
Answer: This is another example of where a PYREX brand glass solved a critical design problem, this time because of its low coefficient of expansion and high resistance to abrasion and physical shock.

For a brief rundown on the physical properties of PYREX brand glasses and other glasses, ask for our Bulletin B-83.

### *Godet (or how to spin a yarn)*

Godet is the name given to a highly talented wheel used for spinning rayon yarn.

This intelligence by itself is neither startling nor revealing. And this picture tells you little other than that godet wheels are made of glass in dimensionally accurate intricate shapes.



Why we discourse on godet wheels (aside from the fact that we make them) lies in the somewhat unusual circumstances under which they operate.

First, viscose (cellulose solution in a mixture of carbon disulphide and sodium hydroxide) is extruded through a spinnerette into a solution of sulphuric acid. The coagulated yarn, comprised of as many as 800 delicate filaments, must then be pulled out of the acid, washed, and stretched.

Here's where the godet wheels take over. One, with a stream of hot wash solution running over it, pulls the yarn and snubs it. The other puts in the stretch.

And why glass for this chemical yarn spinning? First, there's the very important consideration of *dimensional stability.* This glass has it. Good thing, too, since any change in wheel size or shape, due to the affects of the acid, would change the wheel's peripheral velocity, and adversely affect the yarn stretch.

Moreover, the smooth finish of the glass wheels insures against fraying the fine filaments.

These wheels are also impervious to the corrosive action of both the acid and hot wash water.

And, glass is easily shaped to the complex fluted form required—in quantities, at reasonable prices.

Here's a spinning example of Corning custom engineering in glass—the right balance of the right characteristics—to do a very special type of job.

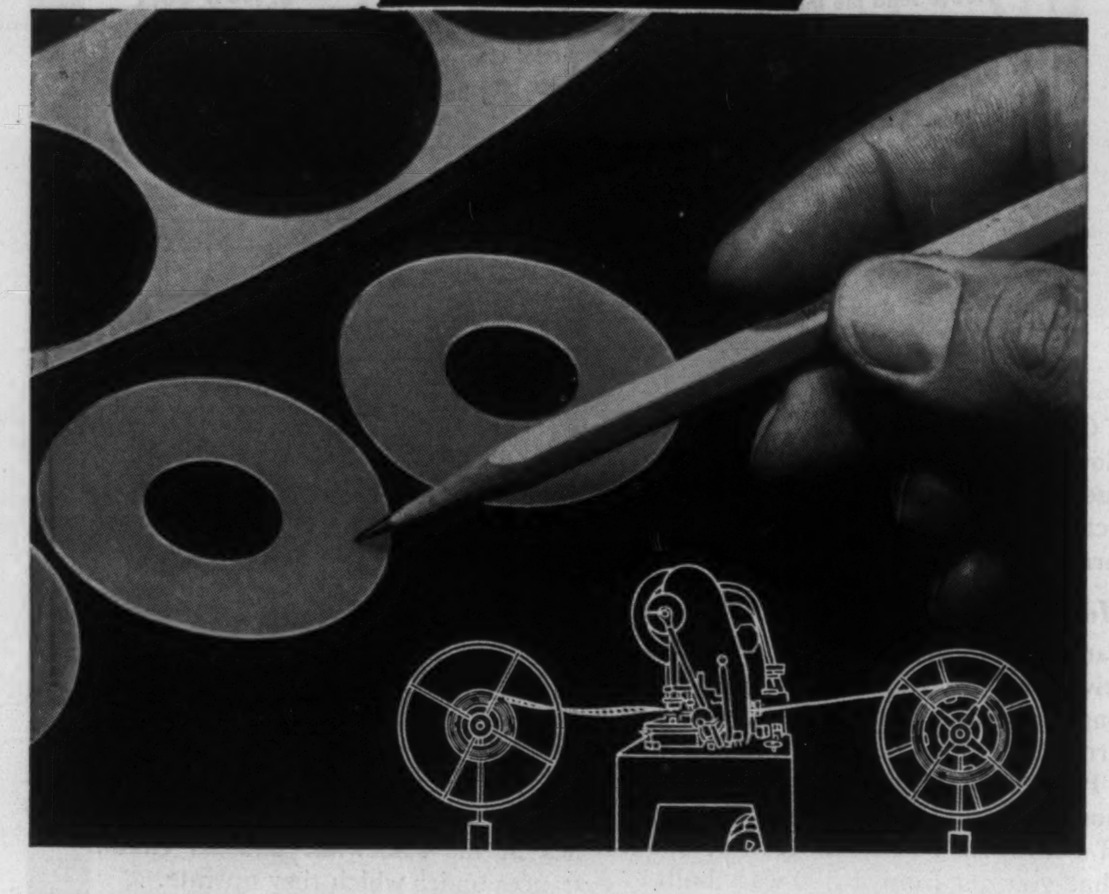
More examples are spelled out in "Glass and You. "It's a good primer for learning a great deal about today's *engineered* glasses. Use the coupon. Free.

**CORNING GLASS WORKS, CORNING, N. Y.**

*Corning means research in Glass*

**For more information, turn to Reader Service Card, Circle No. 408**

POLYPENCO® NYLON SHAPES



## It's like blanking from metal strip when you make Nylon parts this way

- Blanking from POLYPENCO nylon strip now enables *every* designer to get nylon's resiliency and wear resistance in lock washers, thrust bearings, gaskets, and other thin parts. With this strip, nylon parts are blanked just like metal components. The dies are practically the same, and your operators use exactly the same punch presses, techniques, and feeding methods. What's more, production costs are low. Press speeds up to 600 cycles per minute have been successfully obtained. POLYPENCO nylon strip is available in standard widths of ¼" to 4" and in thicknesses from .010" to .125". With POLYPENCO nylon shapes, you always get these advantages:

- Direct control of fabrication on the standard metal-working tools in your own shop.
- Design flexibility . . . closer tolerances in many cases.
- Immediate warehouse delivery of most sizes.
- Uniform high quality . . . technical help.

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For more information, turn to Reader Service Card, Circle No. 373

**Meetings & Expositions**

GRAY IRON FOUNDER'S SOCIETY, annual meeting. Milwaukee. Oct. 19-21, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Oct. 24-25, 1955.

AMERICAN STANDARDS ASSN., annual meeting and national conference on standards. Washington, D. C. Oct. 24-26, 1955.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Oct. 26-28, 1955.

MAGNESIUM ASSN., annual meeting. New York. Oct. 31-Nov. 1, 1955.

INVESTMENT CASTING INSTITUTE, fall meeting. Detroit. Nov. 1-3, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, Diesel Engine meeting. St. Louis, Mo. Nov. 2-4, 1955.

METALS CASTING CONFERENCE. Lafayette, Ind. Nov. 3-4, 1955.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Diamond Jubilee annual meeting. Chicago. Nov. 13-18, 1955.

NATIONAL METAL TRADES ASSN., annual convention. New York. Nov. 14-16, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual technical and operating conference. Cleveland. Nov. 16-18, 1955.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. Chicago. Nov. 16-18, 1955.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, electric furnace steel conference. Pittsburgh. Dec. 7-9, 1955.

NUCLEAR CONGRESS AND ATOMIC EXPOSITION. Cleveland. Dec. 10-16, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit. Jan. 9-13, 1956.

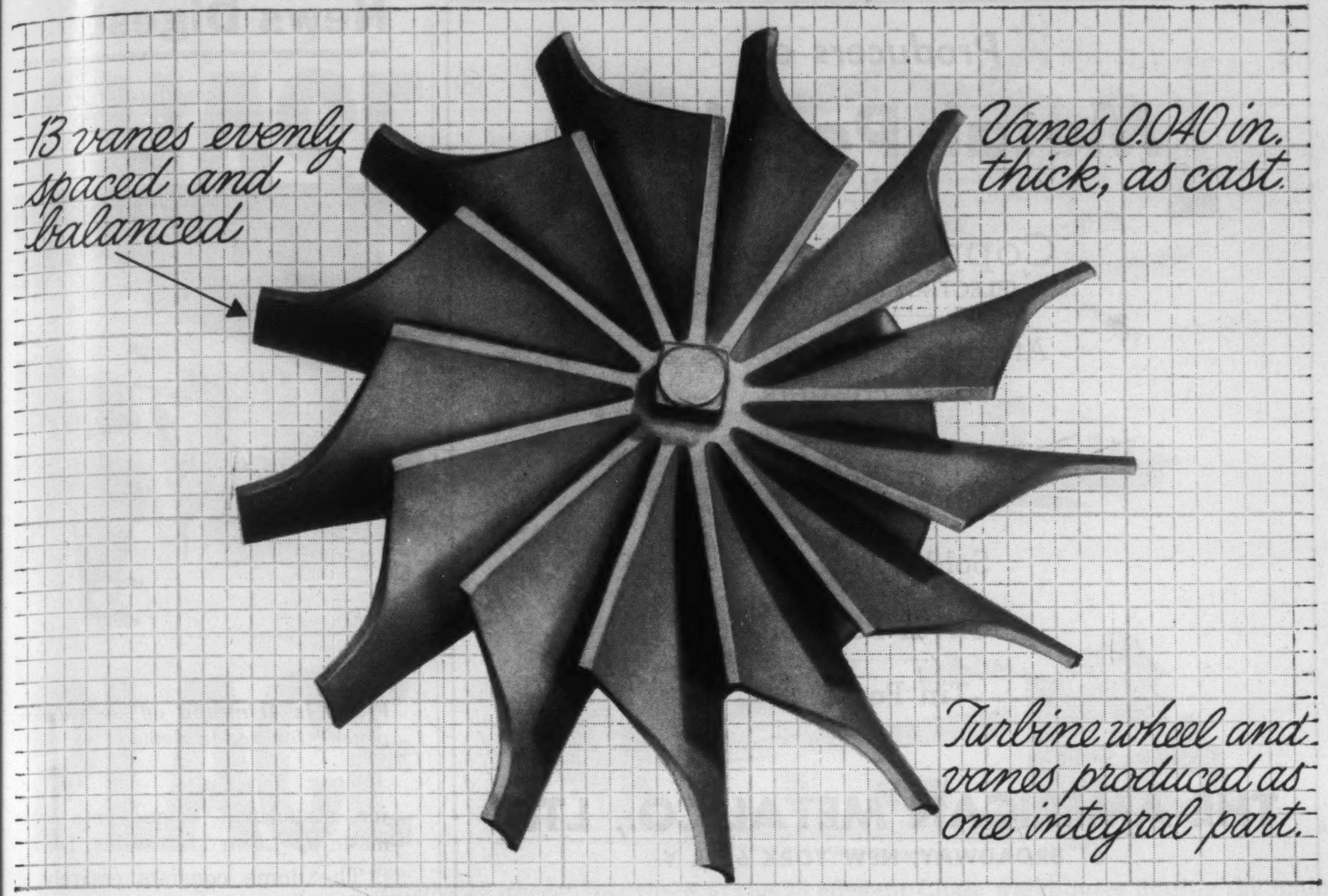
SOCIETY OF PLASTICS ENGINEERS, annual conference. Cleveland. Jan. 18-20, 1956.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Buffalo, N. Y. Feb. 27-Mar. 2, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar. 6-8, 1956.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar. 15-16, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, national production meeting and forum. Cleveland. Mar. 19-21, 1956.


13 vanes evenly spaced and balanced
Vanes 0.040 in. thick, as cast.
Turbine wheel and vanes produced as one integral part.

# Tough Design Problem Solved by Investment Casting ....

The precision-investment-casting process proved to be the most practical and economical way to produce an efficient turbine wheel for a diesel engine supercharger. The wheel rotates at 42,000 rev. per min. and is exposed to a 1450-deg. F. temperature. It had to be made of a hard-to-machine alloy capable of standing up under these severe service conditions. Yet, to operate efficiently, the vanes of the wheel had to be extremely thin and formed to an intricate shape.

The vanes and wheel were produced as one integral part by HAYNES' precision-investment casting process. Only two simple finishing operations were needed to put the wheel in service. The vanes are only 0.040 in. thick . . . too thin to produce by other methods without a prohibitive amount of machining on a hard, tough alloy.

The successful production of this turbine wheel points up one of the big advantages of HAYNES' precision-investment casting process . . . the planning freedom it offers to design engineers. For the full story on how this modern mass-production method can help you, contact one of the District Sales Offices listed below.

**HAYNES**
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**HAYNES STELLITE COMPANY**
**A Division of Union Carbide and Carbon Corporation**
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*"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.*

**For more information, turn to Reader Service Card, Circle No. 381**

For more information, turn to Reader Service Card, Circle No. 346

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**Metal Powders**

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(ELECTROLYTIC GRADE)

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WING SCREWS
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THUMB SCREWS
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GRC

here's what **DIE CAST GRC** ZINC ALLOY THREADED **FASTENINGS** mean to you...

**In terms of a better product, in terms of a more economical product!** Gries' unique techniques make possible closer tolerances, cleaner threads, greater dependability, durability, die-cast uniformity. Mass production means lower costs!

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Fact-packed—shows how Gries ingenuity and money-saving methods can solve your fastenings problems.
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*World's Foremost Producer of Small Die Castings*

For more information, turn to Reader Service Card, Circle No. 510

## News Digest

*continued from p. 13*

***Flash is trimmed** off molded component for radar dome.*

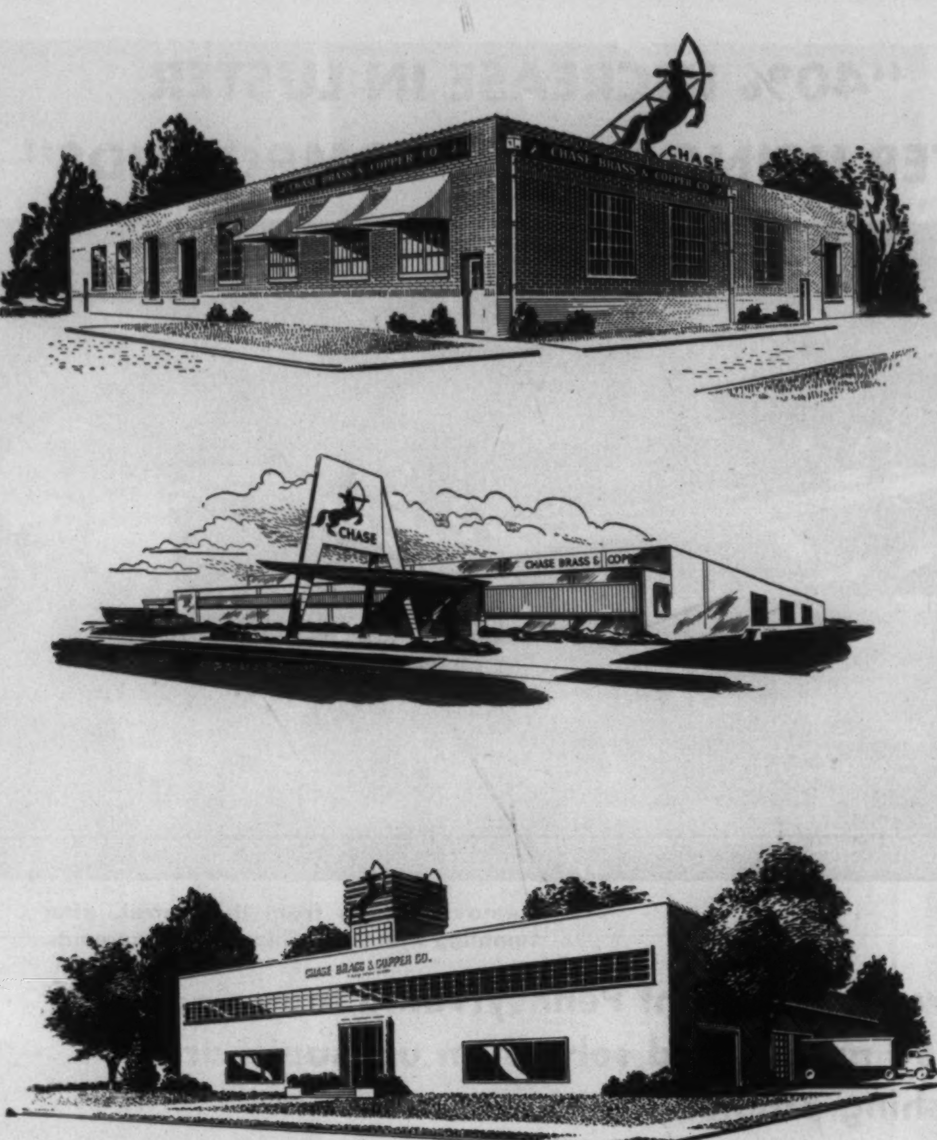
jor structural components were made by Lunn Laminates, Inc.

The dome consists entirely of sections of glass mat-reinforced polyester molded with integral flanges and bolted together. Neoprene rubber gasketing bonded to molded-in grooves makes all joints weather-tight. The skin is about 0.050-0.060 in. thick and the flanges are about 1/8 in. thick. Although cost has not been revealed, it is believed to be in the neighborhood of $100,000.

Known as a "Geodesic" dome, this type of structure was invented by the controversial Buckminster Fuller. It is extremely light in weight—only six tons—and its relatively small components and ease of assembly make it simple and economical to ship and erect. A crew of eight men, having no experience with this type of structure, needed only only 288 man-hours to assemble and erect the 363 parts of the radar dome. Although the Geodesic dome appears flimsy compared to more conventional structures, it was designed to withstand winds up to 200 mph.

The sphere's design is based on flat equilateral triangles. The typical molded section is a two-plane diamond made up of two 4-ft tri-

# CHASE® IS THE PLACE FOR STAINLESS STEEL!



*Illustrated above:* **Just three of the 25 efficient Chase warehouses dotting the nation.**

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**BRASS & COPPER CO.**

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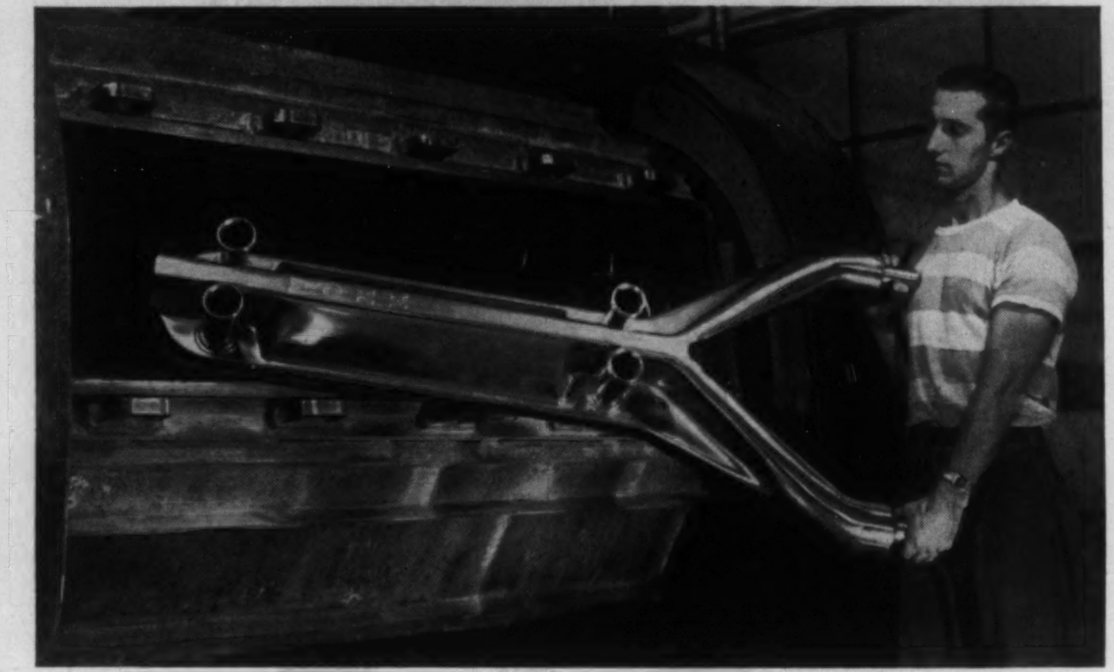
St. Louis
San Francisco
Seattle
Waterbury

For more information, turn to Reader Service Card, Circle No. 451

"40% INCREASE IN LUSTER AFTER USING LORCO COMPOUNDS"



Removing parts from the barrel, after tumbling with Lorco Chips and Compounds.

**How an important Pennsylvania manufacturer saved money and solved an unusual barrel-finishing problem.**

A large eastern corporation was exploring the possibilities of barrel-finishing stainless steel frames and heat exchanger units.

These frames, measuring 56" x 25", required specially designed fixtures to hold them in the barrel. The first try, according to the manufacturer, was a dismal failure. Numerous types of compounds and chips in varying combinations were experimented with, but none proved satisfactory and costs seemed prohibitive.

Finally, the only way they could do an acceptable job was to scrub the parts by hand with a brush and a soap detergent after tumbling. *And then they learned about LORCO COMPOUNDS!*

Using fused aluminum oxide chips and Lorco Compounds for 20 minutes, a load was washed down and the parts removed. Immediately it was apparent that the luster was greatly improved. Subsequent examination with a Gardner Glossmeter showed an increase in luster of 40% *over anything which had been previously tumbled.* In low costs, Lorco compounds were also winners . . . 39% *under the costs of other compounds.*

*If you have a tough barrel-finishing problem, be sure to try Lorco Chips and Compounds. Today they are offering truly amazing answers to the problems of scores of manufacturers . . . for thousands of parts . of all shapes and sizes. Write for detailed information about our free sample processing service and your copy of the new manual, "The Lorco Method of Precision Barrel Finishing."*

Lorco

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MANUFACTURERS OF BARREL FINISHING COMPOUNDS
TUMBLING BARRELS — MEDIA AND AUXILIARY EQUIPMENT

For more information, turn to Reader Service Card, Circle No. 467

**Rubber gaskets** *are bonded to the edge of finished section.*

angles with a reinforcing rib along the dihedral. Circular elements eliminate multi-joint intersections that would be difficult to seal properly.

Buckminster Fuller, known almost universally as "Bucky," is widely known for his system of "Energetic Geometry"—a mathematical system relating energy and spatial patterns. He uses his rigorous geometry to create structures utilizing more efficiently the known properties of engineering materials. He claims his system provides better and potentially less costly structures than those of today.

In addition to the Geodesic dome, the best known results of Fuller's philosophy have been his so-called Dymaxion house (suspended from a central mast) and his Dymaxion car (a stable three-wheeler with the versatility of a jeep). Both are considered too radical for commercial acceptance.

The most widely publicized Geodesic dome covers Ford Motor's rotunda in Dearborn, Mich. Made of aluminum struts, it is 93 ft in diameter and weighs 8½ tons (about 1/29th the weight of a conventional dome). It was assembled in one-tenth the time and

See what adhesives are doing today!

# Taking the noise out of sound

3M COMPANY

With movable wall panels, like those pictured above, you can build a room anywhere—in the factory, in the office, in the laboratory. But the new room would be impractical unless it were protected from outside vibration and noise. That's where 3M comes in. EC-1000 is a vibration and sound damping coating that withstands high temperatures directly after application. Immediately after EC-1000 is sprayed on the back side of the metal panels, they are primed and run through the baking ovens! There's no lost motion . . . no production line slowdown. And once installed, walls treated with EC-1000 make a room that is quieter, easier to work in, relatively unaffected by external noise and vibration.

**See what adhesives can do for you...**

Perhaps you have a production problem 3M can help you solve. A 3M field engineer will be glad to consult with you on your specific requirements. Or, for a free booklet on cost-cutting 3M adhesives, write 3M, **Dept. 610, 417 Piquette Av., Detroit 2, Mich.**

*ADHESIVES AND COATINGS DIVISION* **MINNESOTA MINING AND MANUFACTURING COMPANY**

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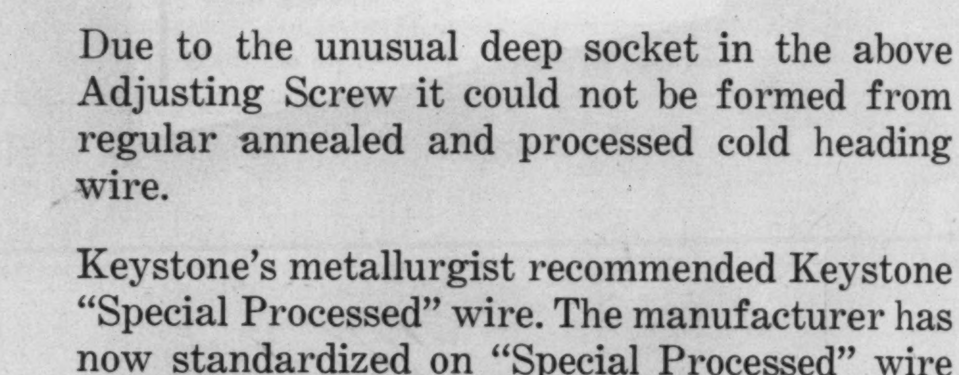
FROM THIS
TO THIS
...at Lower Cost per Unit with
KEYSTONE
"SPECIAL PROCESSED"
COLD HEADING WIRE

Due to the unusual deep socket in the above Adjusting Screw it could not be formed from regular annealed and processed cold heading wire.

Keystone's metallurgist recommended Keystone "Special Processed" wire. The manufacturer has now standardized on "Special Processed" wire for this and other difficult cold headed parts. His results have been improved quality, increased production and lower cost per unit.

The superior grain flow characteristics of Keystone "Special Processed" wire provide the necessary upsetting and die forming qualities to withstand the terrific metal displacement in your most difficult cold heading jobs. Your inquiry is welcomed.


Keystone Steel & Wire Company
Peoria 7, Illinois
Industrial Wire Specialists

For more information, turn to Reader Service Card, Circle No. 482

## News Digest

cost about one-fourth as much as a conventional dome.

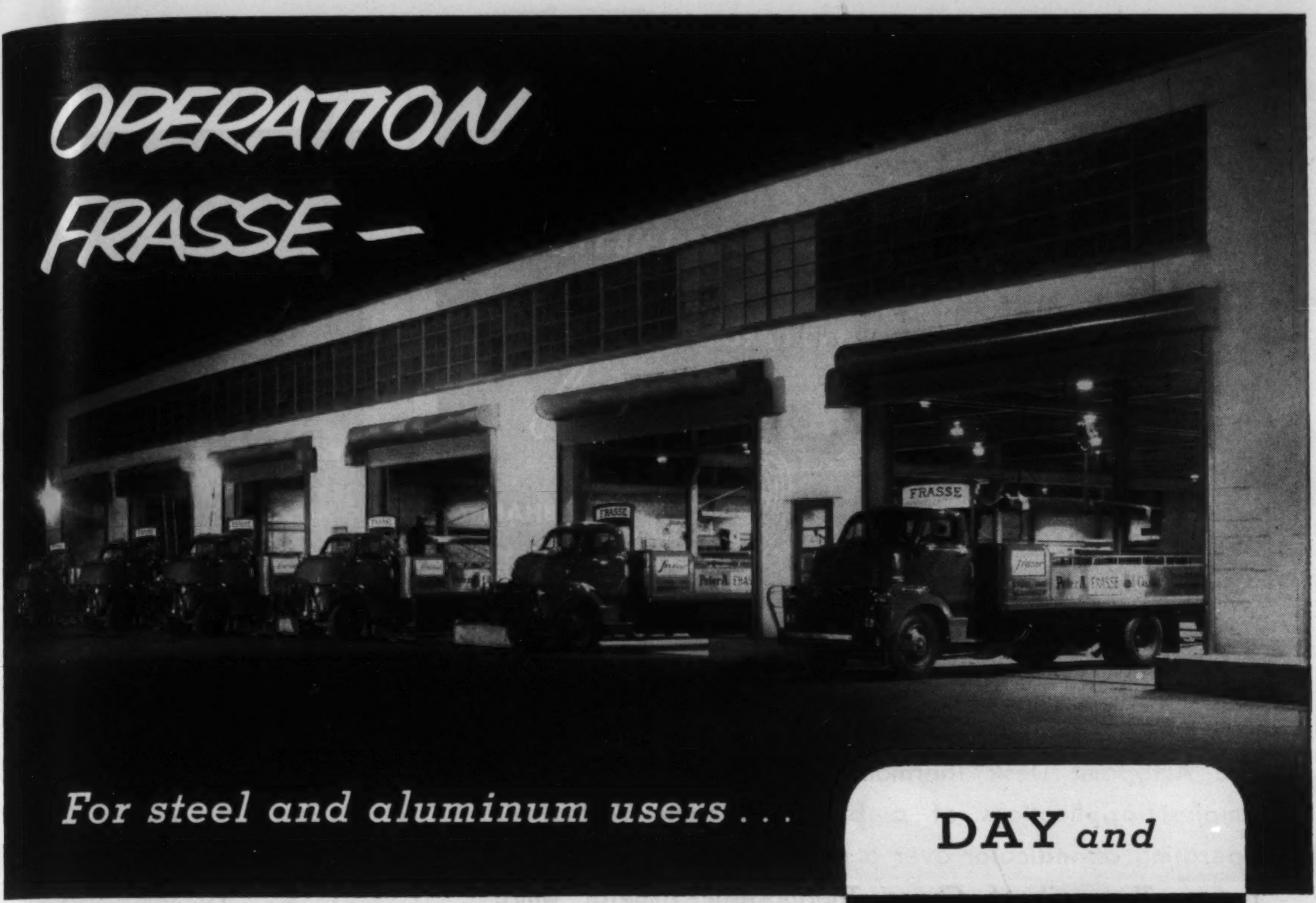
Other Geodesic domes are being tested by Marine Corps Aviation to replace tents as mobile shelters. Ranging up to 117 ft in diameter, they are made of aluminum or magnesium extrusions and covered with a three-layer sandwich of glass wool and neoprene-coated nylon cloth. They weigh about 3% as much as existing shelters, require only 6% of the packaged volume, require less than 1% of the man-hours for construction, and cost only 14% as much. Whereas tents collapse in 50 mph winds, and most prefabricated shelters withstand winds up to 80 mph, the Geodesic shelters will take winds up to 150 mph.

Fuller has yet another type of dome shelter on the drawing board — an aircraft hangar that will enclose about two million square feet of floor space, house a plane 20 times its own weight, and require only five man-hours to erect.

Reinforced plastics, despite their relatively low modulus, have a particular appeal to Bucky Fuller. As Geodesic structures become larger, reinforced plastics become increasingly advantageous compared to the light metals. For structures beyond a certain size, he says his calculations show that the only engineering material feasible is reinforced plastics.

For many applications, the practicability of Geodesic or Dymaxion structures depends upon the development of markets large enough to bring down the cost of the required materials which, in general, are far more costly than the materials ordinarily used in the construction industries. Meanwhile Bucky Fuller seems to be determined to keep developing new and intriguing applications—a ball park enclosed by a Geodesic dome is on his list—in the hope that the necessary public acceptance and investment capital will someday be forthcoming.

*(More News on page 242)*



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Frasse stocks *all* of the popular grades, shapes and sizes of stainless, alloy and carbon steels, tubing and aluminum . . . plus many specials, too. When you work from complete Frasse warehouse stocks you eliminate needless "shopping".

And, remember — Frasse engineers are always available to consult with you on problems involving steels, tubing and aluminum. Their services are free, and they can be consulted anytime — by mail, phone . . . or on the spot in your plant.

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LYNDHURST ROCHESTER BALTIMORE

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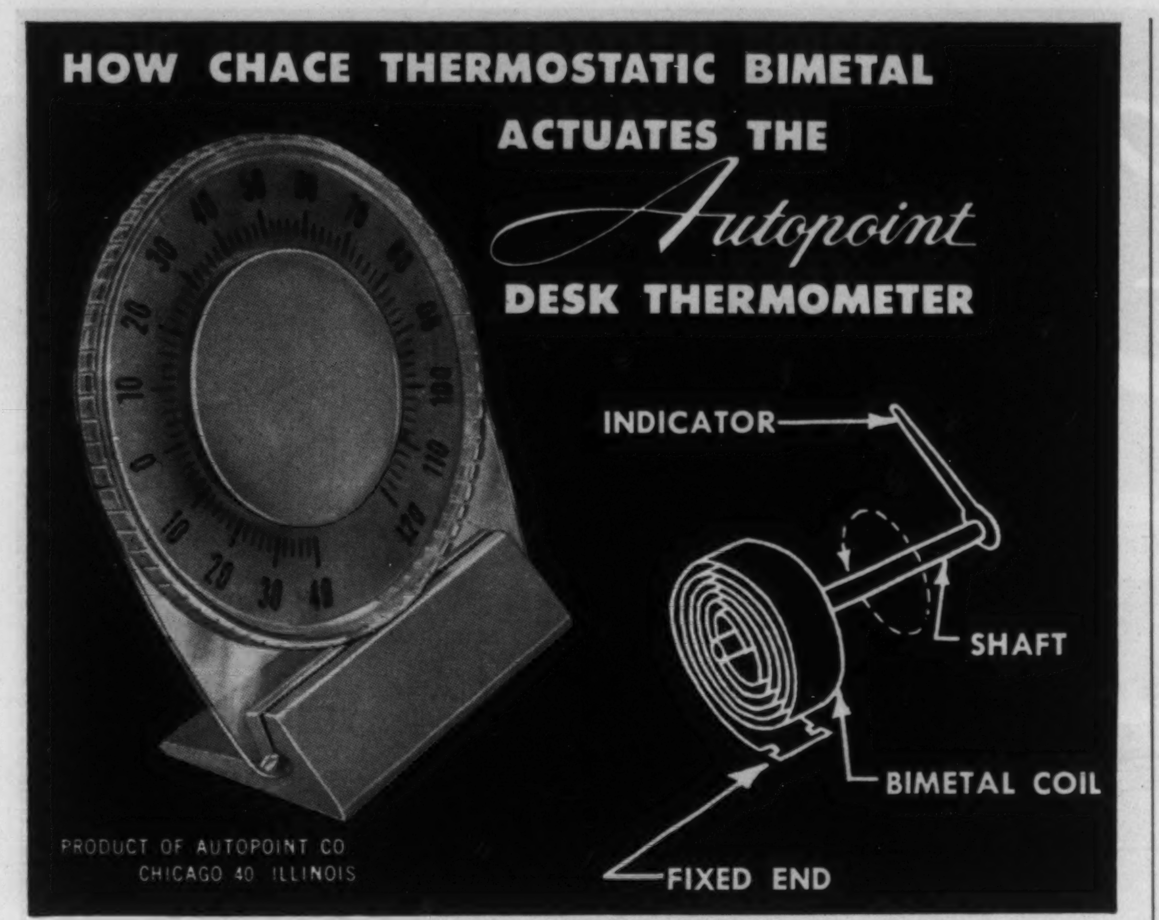


The Autopoint Desk Thermometer illustrates one of the simplest applications of a bimetallic element—that of operating an indicator over a predetermined temperature range. The coil of Chace Thermostatic Bimetal which actuates this device is calibrated at the factory to assure precise temperature readings over a long period of time. Since this thermometer is also used to indicate more extreme outdoor temperatures, it has an effective range of −40°F. to +120°F. This application requires a bimetal material with a high deflection range and high torque properties, such as is found in Chace No. 2400 Thermostatic Bimetal.

A coil of Chace Thermostatic Bimetal is securely anchored at its one end to the backplate of the thermometer. The other end of the coil is fastened to the stem of the dial indicator. Temperature variations between −40°F. and +120°F. cause the coil to rotate in a predetermined arc, moving the indicator to register the correct ambient temperature.

**Chace Thermostatic Bimetal is available in 29 different types, in strip and coil forms, as well as in completely fabricated elements made to customer specifications. Write now for our free 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal."**

**W. M. CHACE CO.**
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, Circle No. 452

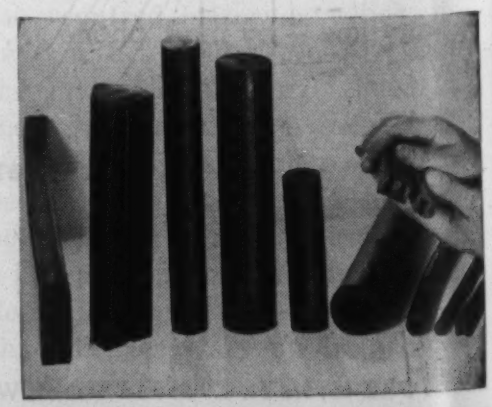
## News Digest

***Continuous - molded** soft rubber hose is shipped on reels. Previous maximum length for such material was 6 ft.*

## Continuous Molding for Soft Rubber

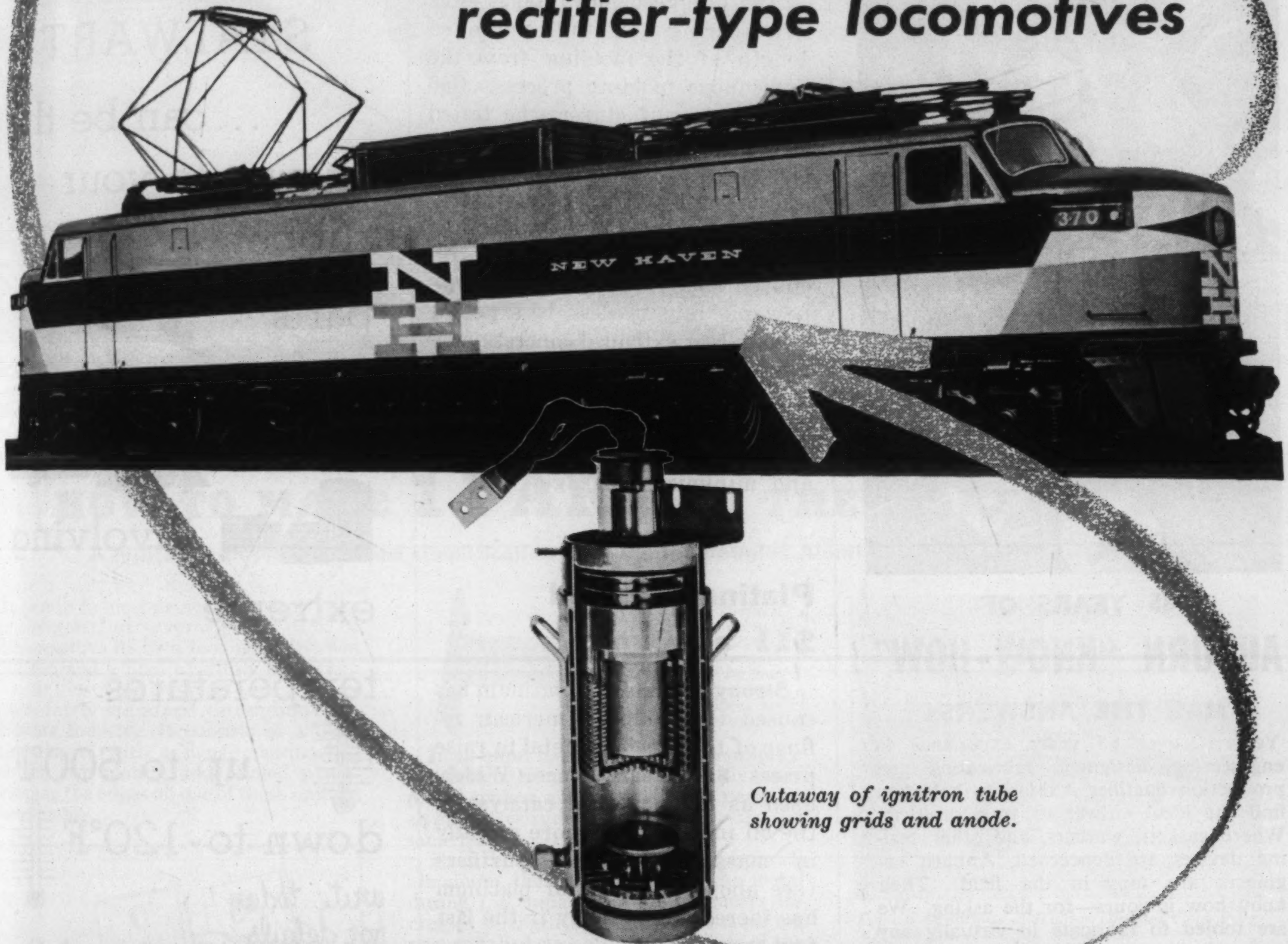
A new molding process for low durometer rubber is turning out reels of extrusion-like rubber shapes of unlimited length. Called continuous molding, the process was developed by U. S. Rubber Co., and is now in production. The molding process is claimed to be as accurate as press molding, yet faster and much cheaper. Because the process turns out unlimited lengths of rubber sections, considerable economies are possible for rubber consumers, who were previously limited to short lengths of press formed moldings. Scrap loss is cut significantly, as is splicing cost.

The process is far more exact than extrusion, and has the further advantage of handling softer,



***Variety of shapes** and sizes of continuous molded soft rubber parts.*

# Speer carboneered IGNITRONS power New Haven's ten new rectifier-type locomotives



*Cutaway of ignitron tube showing grids and anode.*

**Twelve G-E double-grid ignitron rectifier tubes** supply d-c power to the New Haven Railroad's new 4000-horsepower locomotives. Each tube contains a Speer graphite shield grid, control grid, and anode. These parts are made of the finest grade graphite—free of impurities that cause arc-back and flash-over.

Precision-machined shield and control grids are designed to operate at voltages up to 500 volts—the anodes at voltages up to 4000 volts. Speer graphite electrodes withstand high overloads without melting. In addition, their coefficient of expansion is so small that there is no warp or distortion.

Applications of carbon products throughout industry are virtually limitless. Speer *Carboneering* has contributed vastly in fulfilling unusual design and material requirements. Let our experienced designers and engineers help you *Carboneer* a practical solution to your parts problem.

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**St. Marys, Pennsylvania**

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more resilient rubbers. Seals for concrete pressure pipe, forms for concrete slabs, and engine mountings are currently in production at U. S. Rubber. Seals for double window, sink spray hose, and windshield wiper tubing are under test.

The biggest advantage over press-curing is the unlimited length of the molding from the continuous molding process. One window manufacturer who tested the continuously molded double window seal found that only one splice per window was necessary. This compared to several splices and unavoidable scrap loss with conventional 6-ft lengths. The new molding process is expected to supplant extruded concrete pipe gaskets that were often too hard and not accurate enough. Soft rubber gaskets of continuously cured stock assure an accurate fit and minimize breakage.

## Platinum Upped $11 an Ounce

Strong demand for platinum has caused the leading American refiner of the precious metal to raise prices $11.00 an ounce. Widely used as an industrial catalyst in the oil industry and more recently in mass-produced air purifiers (see above), the use of platinum has increased markedly in the last few years.

Domestic use of the metal, according to Baker and Co., has exceeded the refining capacity to the extent that supplies must be purchased from high cost foreign sources. In Europe, prices have ranged from $90 to $92 an ounce, compared to $80 to $81 an ounce, in the U.S.

Industrial uses of platinum include electrical contacts, chemical catalysts, and laboratory equipment, such as weights, crucibles, etc. For most applications, platinum metal is used in its pure state because of its superior corrosion resistance and unique chemical properties.

(More News on p. 246)

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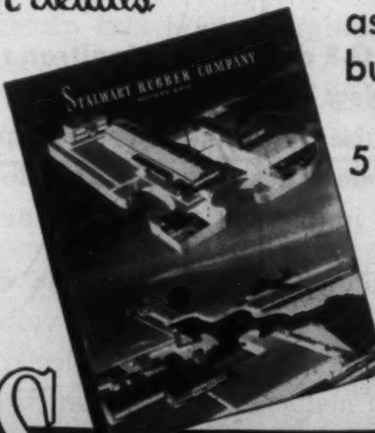

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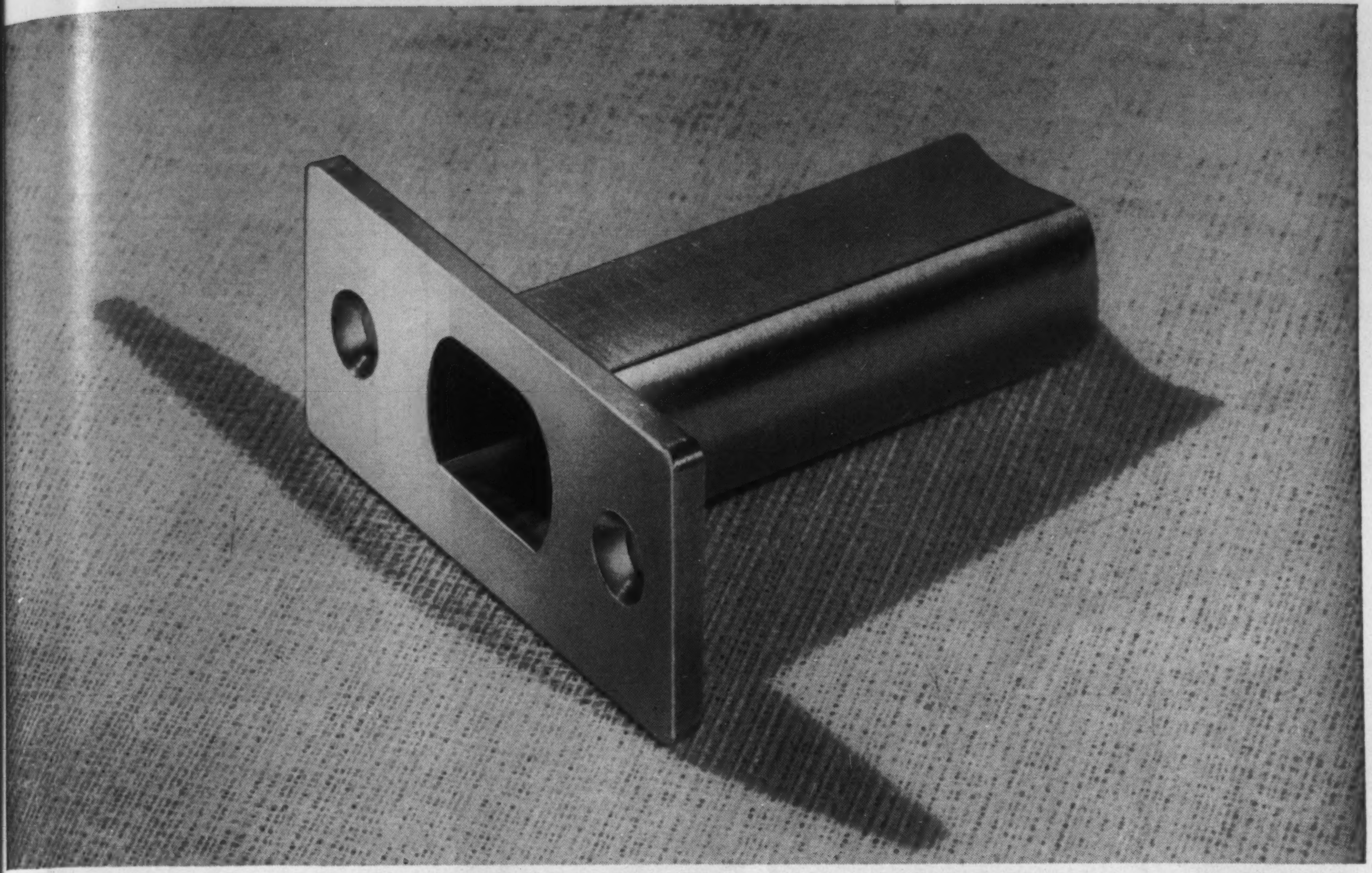
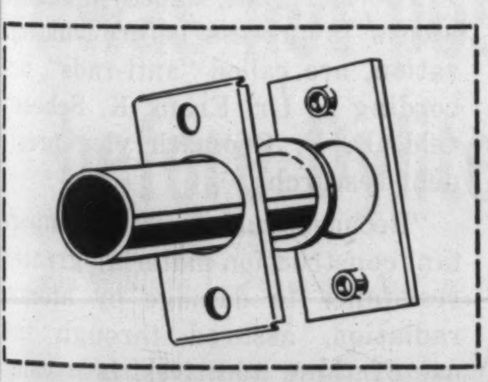


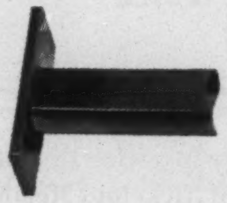
# HOW TO MAKE 1 PART DO THE WORK OF 3

**A typical example of product simplification with Hunter Douglas Aluminum Impact Extrusions.***

The barrels in most present day door locks are composed of several parts, each of which requires its own tooling, individual press run and a final assembly operation. The part illustrated is typical and construction is fairly standard throughout the hardware industry. It consists of a deep drawn barrel with a flange sandwiched between two mating and piloted plates. Crimping the edges on one of these unitizes the assembly.



*Conventional manufacture of this latch bolt includes individual formation of these three pieces plus final assembly and a crimping operation.*



*Notice the square shoulder formed between barrel and flange. No fillet is required—strength is increased by flow of metal around juncture; fibers remain unbroken.*

In an effort to reduce costs and simplify this design, Hunter Douglas recently completed tooling and supplied test parts on an impact extruded component serving the same function.

Even though the part was made from 2S aluminum, the cold working of the metal during the impact extruding process increased strength materially. The resulting part equalled strength requirements of the original design. In addition, the flange was integrally formed with the barrel, without need for joints, seams or fasteners. Impact extruding also insured both zero draft walls of tube and close dimensional tolerances.

The required barrel was unusual—a cylindrical shape with flattened sides. Again, impact extruding proved a most logical means of manufacture... desired part geometry being a direct result of die design and requiring no subsequent forming operations. Actual unit cost of the impact extrusions proved economical—without counting the savings made in tooling.

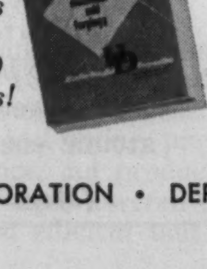
*Typical variations of Hunter Douglas Cold Forgings which serve many industries.*

If you are planning design changes or require a hollow component—with or without a closed end—in which zero draft, close tolerances, and high strength factors are desirable, a Hunter Douglas Aluminum Impact Extrusion or Cold Forging might supply the answer. A blueprint, sketch or sample part will bring a quick analysis from our engineering department.

**Hunter Douglas distinguishes parts as Impact Extrusions when formed from soft (2S) aluminum. Parts made from high strength aluminum alloys are designated Cold Forgings.*

**DESIGNERS:**

*If you want to know more about Hunter Douglas Aluminum Cold Forgings write on your company letterhead for this free 40 page book, now on the press!*



**Hunter Douglas Corporation**

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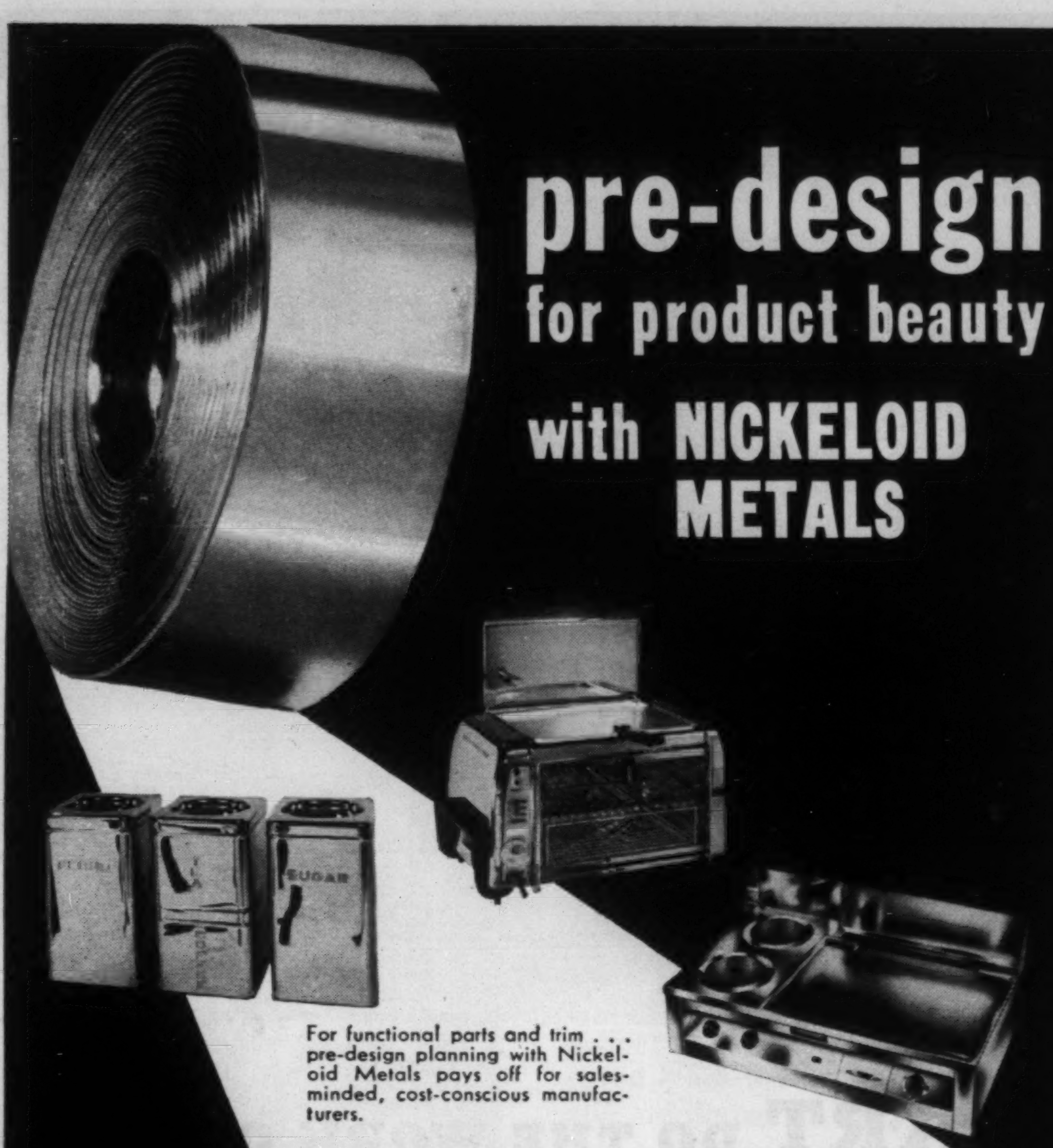

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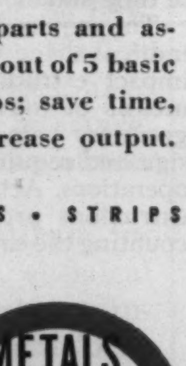

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To protect the brilliantly finished surface during drawing and forming operations, and in handling, Nickeloid Metals are available with MAR-NOT — a protective covering that affords absolute protection until final assembly; then may be peeled off. **Write for full details.**

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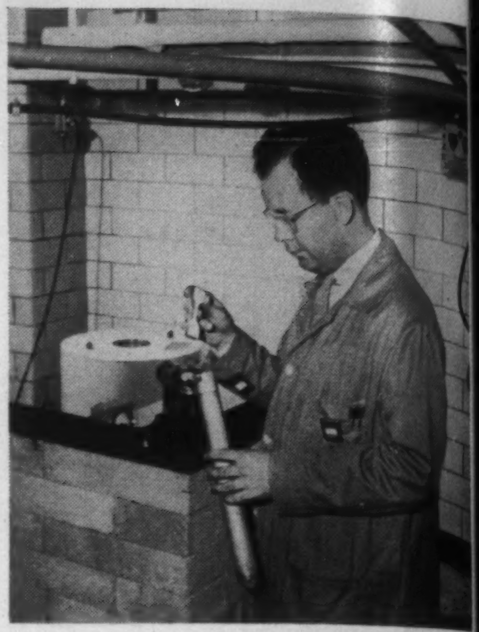
## News Digest



***Rubber sample,** containing "anti-rads" is placed in a cannister for exposure to radiation from cobalt-60 source.*

### Additives Can Improve Radiation Resistance of Rubber

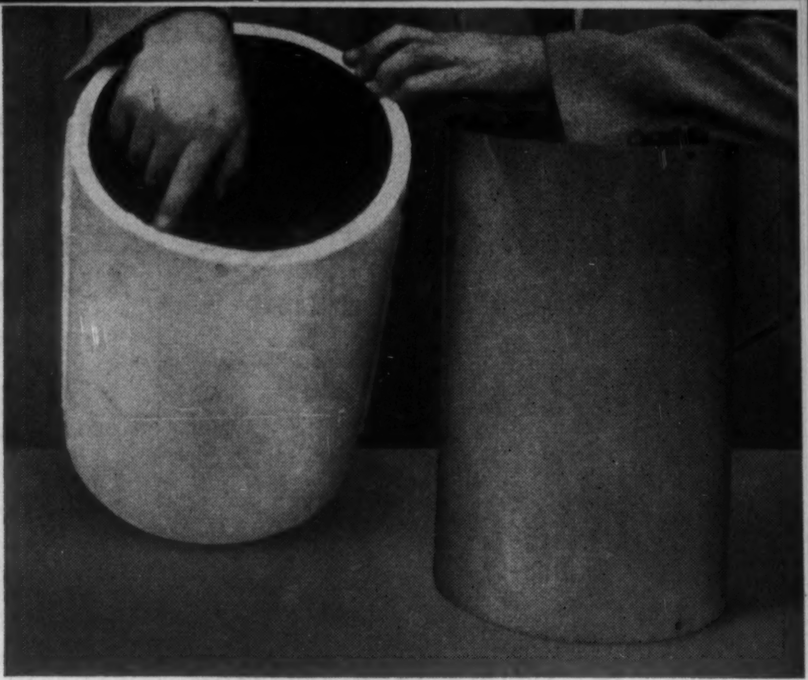
Discovery of materials that extend the service life of rubber, and rubber products, at least ten times when exposed to atomic radiation was announced recently by The B. F. Goodrich Research Center.

The materials, added to rubber stocks in process before vulcanization, are called "anti-rads", according to Dr. Frank K. Schoenfeld, B. F. Goodrich vice president-research.

"Because rubber is an important construction material, greater resistance to damage by atomic radiation, assured through the use of these additives, is a valuable contribution," Dr. Schoenfeld said.

"Growing emphasis on uses of atomic energy requires that construction materials be able to withstand radiation. The discovery, made by the research team assigned to this project, will be useful to both military and industrial development in the field of atomic energy."

*(More News on page 248)*



Gear case, bowl and hopper castings are insulated with a ½" thick shell of Dylite expandable polystyrene. Pre-expanded Dylite beads are placed in a mold around the castings. 270° F. steam further expands the beads, binding them tightly to the castings. The completely insulated parts are then assembled in the machine.

# "It was not possible to produce this machine before Dylite* Expandable Polystyrene"

says **William L. Parsons,** *Asst. to the President,* **Brockman Tool & Manufacturing Co., Bala Cynwyd, Pennsylvania**

They laughed when we wanted to make a counter type ow ice machine," said Mr. Parsons. "The almost imposble problem lay in finding an insulation that would prevent ondensation from forming on the machine. We needed a aterial to meet these critical requirements: high insulating alue, light weight, low thermal conductivity, high strength, sy moldability and production handling.

"The outstanding success of our new snow ice machines due to the insulating performance of Dylite expandable olystyrene manufactured by Koppers."

"The use of Dylite insulation in our machines has ineased the life of the ice by 100%, reduced insulation cost 37%, eliminated troublesome condensation, minimized mage to electrical motors and wiring, prevented rust and ildew, curtailed maintenance, cut production costs, peritted a more compact package, lowered the weight and, s given us the finest, most efficient unit on the market day."

The unusual physical properties of Dylite expandable polystyrene make it perfect for all types of insulation applications. This new material is also being used for packaging, displays, toys and buoyant marine equipment. For more information send for our free illustrated booklet today. Koppers Company, Inc., Chemical Division, Dept. MM-105, Pittsburgh 19, Pennsylvania.

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For more information, Circle No. 459

## News Digest

### Weathering Test for Porcelain Enamels

An expanded weathering test program for Porcelain Enamels will be undertaken under the sponsorship of the Porcelain Enamel Institute.

The findings of the testing program, which is now in its 15th year, have proven valuable to both manufacturers and users of Porcelain Enamel in architecture, in signs, and other exterior uses of the material, Mr. Oliver, the Institute's secretary, stated.

The tests will be performed by the Institute's research associate at the National Bureau of Standards, who is now James H. Giles, Jr. A newly formed Weathering Test Sub-Committee, chairmanned by Dr. J. J. Canfield of Armco Steel Corp., will function as a Sub-Committee of the PEI Quality Development Committee, and will coordinate the program. The entire program will continue to have the guidance and cooperation of W. N. Harrison and D. G. Moore of the Enameled Metals Section, National Bureau of Standards.

**Test methods**

In carrying out the tests, many different specimens are used. These include: acid resistant types from AA to D (according to PEI standards); numerous colors, and types varying from a full matte to a full gloss. The specimen panels are mounted on specially constructed racks on rooftops in various geographical locations. These specimens are removed from time to time, tested and also compared visually with identical specimens which have been stored in a darkened storage area. Thus the effect of time and exposure on the enamels is determined. In the new program, more than two dozen enamel types will be tested for weather resistance, including the new aluminum enamels. In addition, the Institute is working out a program whereby, for a specified fee, individual companies may submit ex-

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## —This is the Anscoflash Type I flash attachment

Ansco
MADE IN
BINGHAMTON
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## *...The secret behind its compactness is this*

# plastic housing custom molded by Sylvania

The Anscoflash Type I is a highly compact flash attachment offering the camera fan an economical entry into the field of "flash" picture taking.

To achieve this compactness and economy Ansco designed a unique plastic housing . . . one which would serve both as a reflector base and battery case.

All parts of the Anscoflash Type I are in some way fastened to this plastic housing. That made design of this part complicated and the important question where to get *complete follow through* on such a complex injection molding. Ansco found the answer at Sylvania. That's because Sylvania offers complete "one source" service in custom molding of both thermoplastic and thermosetting materials.

Here's the important point we want to make: However simple or complex your plastic parts, we'd like to make these same facilities available to you. They include an experienced design and engineering staff—expert mold makers—modern automatic molding equipment—metal stamping and forming—and complete assembly if your part requires metal inserts or additions.

Let us meet with you and discuss your next custom-molded plastic parts job. Phone or write Dept. K53S.

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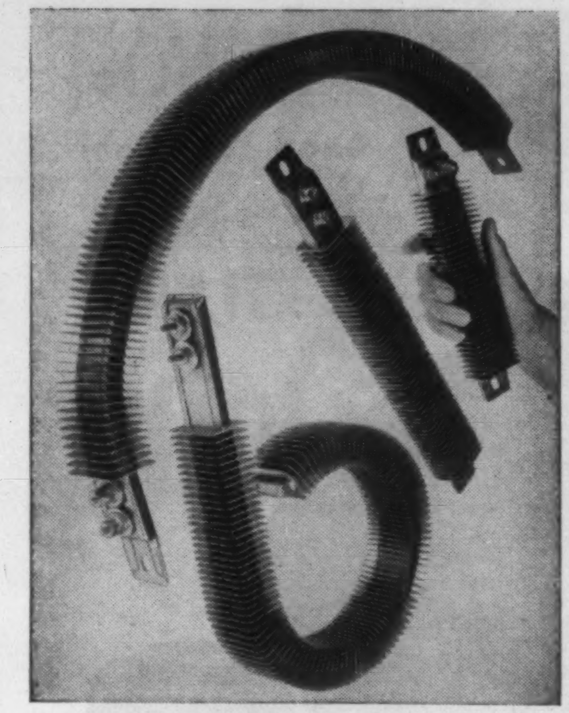

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Easily installed in round or rectangular ducts—separately or in factory-assembled banks.

Parallel fin design dissipates maximum heat with minimum turbulence of air stream. Moisture-proof types available.

**Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.**

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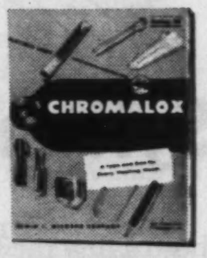

Contains helpful information on design, uses, and prices of complete line of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get some interesting facts about additional applications of electric heat, ask for Booklet F1550—"101 Ways to Apply Electric Heat."

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## News Digest

perimental enamels of their own choosing for testing.

The Weathering Test Sub-Committee, after careful consideration regarding differences in climate and atmosphere, has chosen six test sites: Washington, D. C.; Kure Beach, N. C.; Dallas; Los Angeles; New Orleans; and, to be selected, an industrial site in Cleveland, Pittsburgh, Detroit or Chicago.

### Lithium Gets New Production Plant

Lithium, the lightest metal in the world, is having a heavy impact on American industry.

Discovered in 1817 in Sweden, lithium saw almost no use until the 1880's when lithium hydroxide was employed in the manufacture of Edison batteries, a type still used in mine locomotives and other similar cases.

During World War I, lithium became a tool of war with the use of lithium hydroxide in submarine batteries, and in World War II it performed a mission of mercy with the use of lithium hydride as part of aircraft ditching equipment. Lithium hydride is reacted with sea water to form hydrogen for balloons to mark the location of a downed airplane.

During the past decade, practical uses for lithium compounds have increased so fast that it probably will be several years before industry's huge appetite for the materials can be satisfied.

One of the major producers of lithium chemicals, American Potash & Chemical Corp., plans a sizeable increase of its existing lithium chemicals production as part of the company's current expansion program.

Latest step in American Potash & Chemical Corp.'s lithium plans is the formation of a new company, American Lithium Chemicals, Inc., for which a $6,600,000 production plant is under construction near San Antonio,

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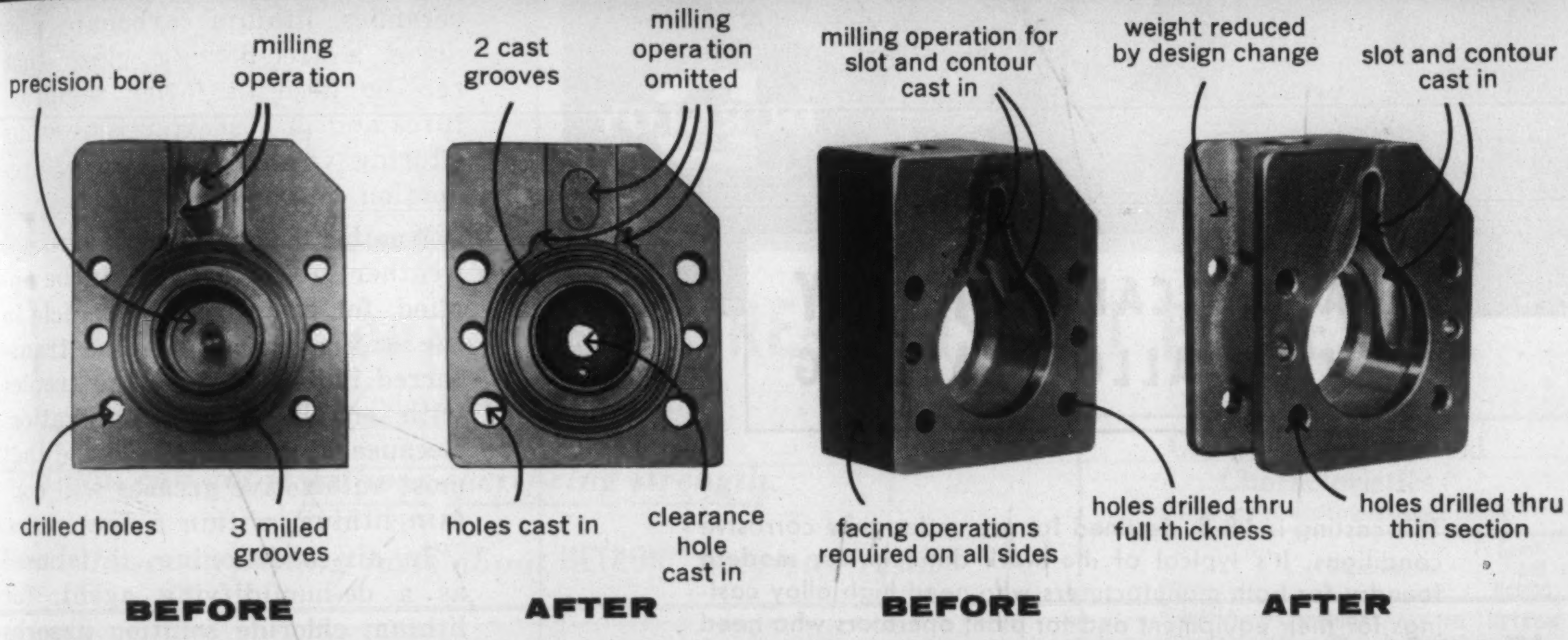
# *In casting pump parts*

# AKH* *makes the difference*

*** Advanced Know-How**


precision bore
milling operation
2 cast grooves
milling operation omitted
milling operation for slot and contour cast in
weight reduced by design change
slot and contour cast in
drilled holes
3 milled grooves
holes cast in
clearance hole cast in
facing operations required on all sides
holes drilled thru full thickness
holes drilled thru thin section
BEFORE
AFTER
BEFORE
AFTER

Machining time on the stainless steel housing for the Vanton "flex-i-liner" pump was cut from 14 hours down to 2 through the use of shell cores; weight was reduced and drilling simplified through casting redesign; and the use of shellcast eliminated the milling on the end plates, making it economical to produce them in stainless steel instead of aluminum. This resulted in a better product in less time and for less money thanks to Cooper Alloy *Advanced* Know-How.

For full details on this specific application write for free copy of case study #2.

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***Foundry Products Division***

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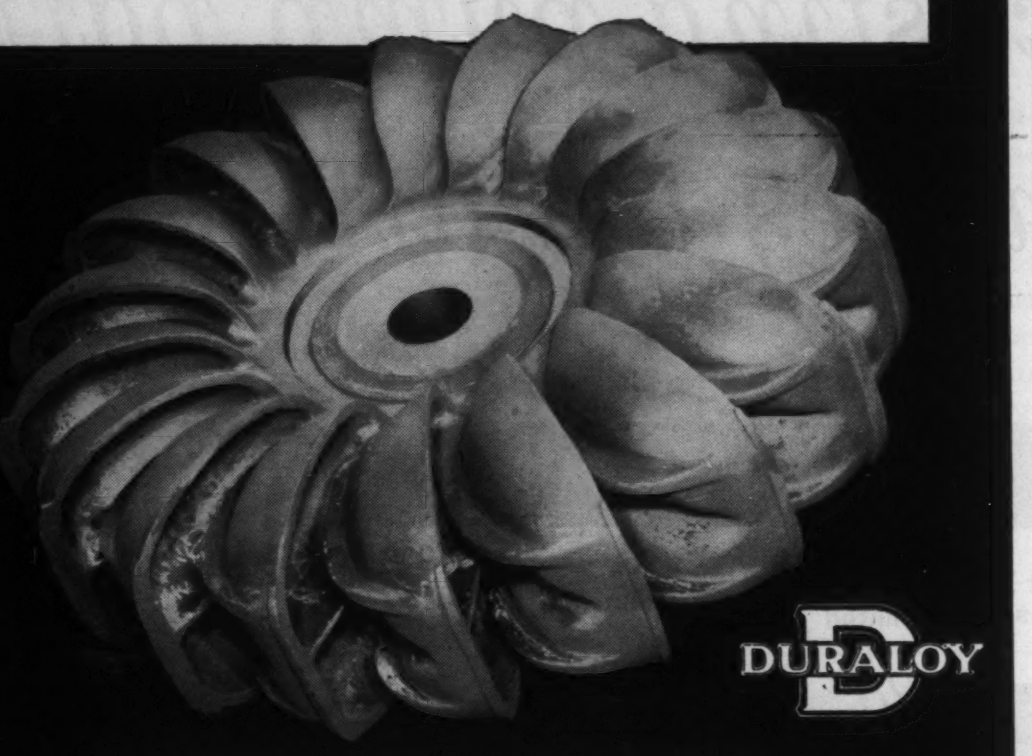
2500 POUNDS OF PUMP RUNNER



A TYPICAL DURALOY
HIGH ALLOY CASTING

This casting is 18-8, destined for use under quite corrosive conditions. It's typical of the work done in our modern foundry for both manufacturers who need high alloy castings for their equipment and for plant operators who need castings to meet a corrosion problem, a high temperature problem or a combination of both, with or without abrasion as a contributing factor.

We here at Duraloy now offer several distinctly different kinds of castings, all in the corrosion-resisting, heat-resisting or abrasion-resisting class and each kind offering certain distinct advantages:

static sand castings
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Shell molding offers great economy in the casting of small pieces on a large mass production basis.

Bring *your* high alloy casting problem to Duraloy both for recommendations as to the best alloying combination and for foundry services in casting and finishing the piece. Our recommendations and service are backed up by more than thirty years high alloy casting experience.

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For more information, turn to Reader Service Card, Circle No. 457

Texas, to produce lithium hydroxide. The plant will be completed, according to schedule, late this year.

At present, the most widespread industrial use of lithium is in carbonate form for porcelain enamel coatings and ceramic glazes. In porcelain enamels such as those used on pans and bathtubs, it results in a lower melting point of the enamel frits, which flow more easily and permit the use of cheaper grades of steel. In ceramics, lithium carbonate produces a free-flowing glaze that can be fired at lower temperatures and in a shorter time, thus offering valuable savings in production cost.

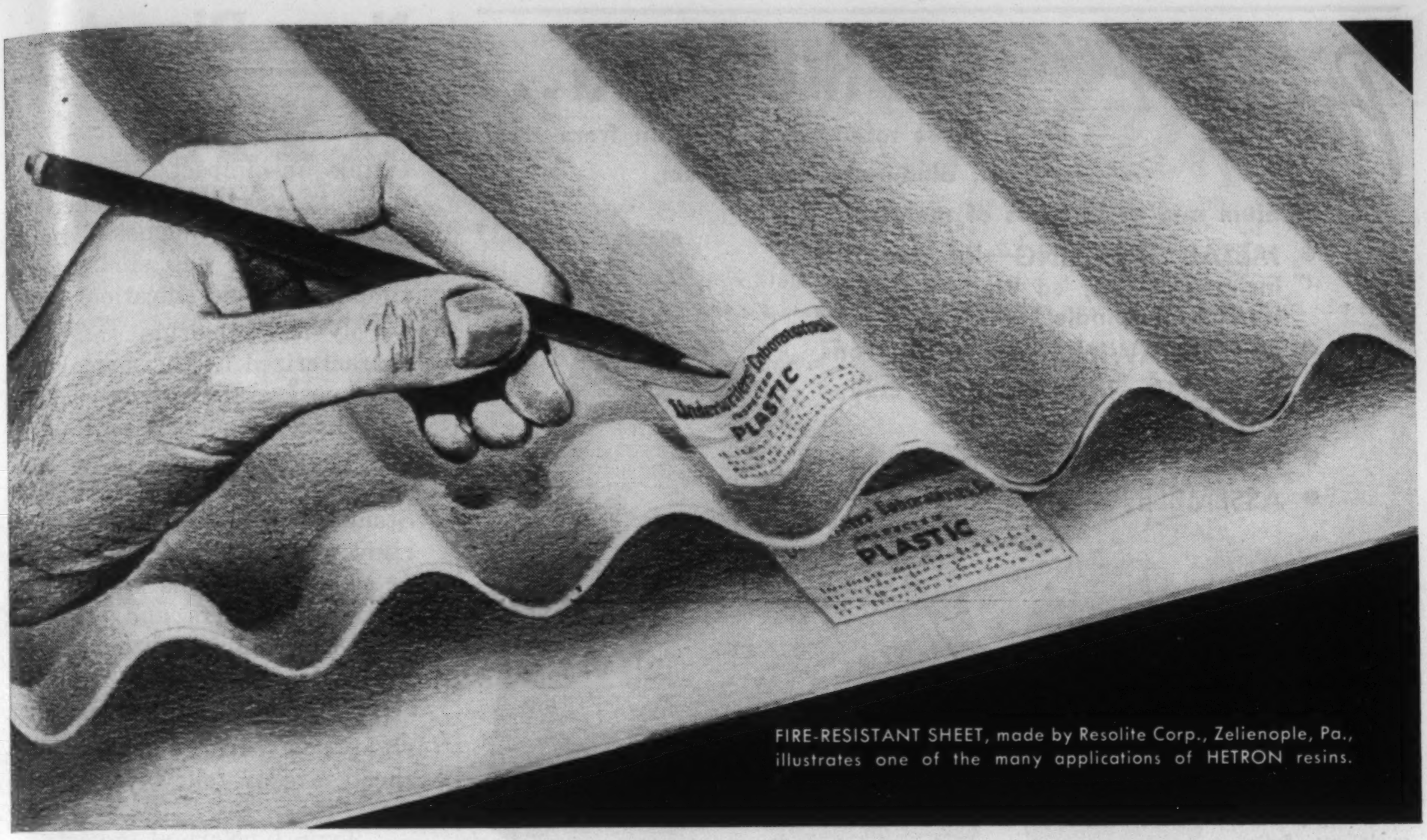
Another major use is in all-weather greases which can be applied, for example, to a vehicle in the Arctic region and then transferred immediately to the tropics with equally efficient operation. Because of this, it is believed that most automotive greases will contain lithium within a few years.

In air-conditioning, it is used as a de-humidifying agent, for lithium chloride solution absorbs large amounts of moisture from the air, which are released when the solution is heated, putting the material in good "working order" once more.

## Rigid PVC Standards

The Recommended Commercial Standard for rigid polyvinyl chloride sheet recommended by the Society of the Plastics Industry has been sent out by the Department of Commerce for industry approval.

The Commercial Standard covers physical and chemical requirements, and methods of test for rigid polyvinyl plastics sheets suitable for fabricating equipment and structures by hot forming and plastics welding techniques. It includes the requirements for two types of PVC—both chemical resistant, but dif-



FIRE-RESISTANT SHEET, made by Resolite Corp., Zelienople, Pa., illustrates one of the many applications of HETRON resins.

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### *Read these surprising facts about* HETRON® *polyester resins*

*Don't* rule out polyester-fibrous glass material on designs calling for a high degree of fire resistance-plus-strength.

You can in all likelihood answer the need with a HETRON-based material.

The inherent fire resistance of HETRON polyester resins make their use possible in many places where glass-reinforced polyester sheet and molded parts have not been permitted.

Light-stabilized HETRON resins now make it possible for you to attain a panel with a high degree of weathering resistance.

**Will not support flame**

Specific flame resistance is chemically, permanently locked into these resins. HETRON will burn only when a hot flame is applied directly to it. It "snuffs out" as soon as the flame source is removed.

Properly formulated HETRON-based sheets have shown flame spreads as low as 20 by ASTM E84-50T in exploratory tests.

**No loss in strength**

You do not sacrifice physical properties when you specify HETRON sheet or molded parts for fire resistance. To the contrary, tests show HETRON is *superior in physicals to most non-fire-resistant resins,* both rigid and semi-rigid. In fact, designers and fabricators have specified HETRON for its physical properties alone—with fire resistance as an added bonus.

For more complete information on HETRON, consult your current copy of Sweet's File (Product Design) or Modern Plastics Encyclopedia. For specific test results, samples of HETRON resins, and names of fabricators who can supply you with HETRON sheet and molded parts, write us today.

**Comparative Physical Characteristics**
HETRON and 10 non-fire-resistant resins

| Physical Property | | Rigid Resins | | Semi-rigid Resins |
|---|---|---|---|---|
| | | HETRON 92 | Avg. 10 Others | HETRON 32 A |
| Flexural Strength, PSIx10³ | Room Temp. | 38.6 | 36.4 | 41.8 |
| | 180°F. | 25.0 | 18.6 | 23.5 |
| Flexural Modulus, PSIx10⁶ | Room Temp. | 1.88 | 1.61 | 1.82 |
| | 180°F. | 0.90 | 0.79 | 0.85 |
| Tensile Strength, PSIx10³ | | 21.7 | 22.0 | 21.0 |
| Water Absorption, Pct. by Wt. | | 0.13 | 0.29 | 0.13 |

SUPERIOR PHYSICALS of HETRON show up in exhaustive tests by independent, impartial laboratories. Panels 0.1" thick, made from HETRON and 10 leading non-fire-resistant resins, contained 35-40% glass mat, 17-20% filler, and the balance resin. Note that HETRON 32A, a semi-rigid resin, is compared with non-fire-resistant *rigid* resins.

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- **ASSEMBLING**

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• Your Drawings and Specifications will bring prompt quotations. Bulletins upon request.

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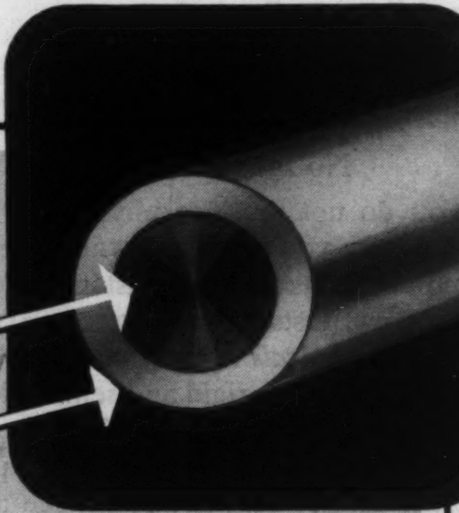

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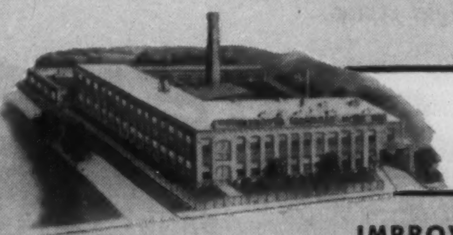
A wide range of precious metal-base metal combinations in sheet, wire, or tubing are quickly available from "IMPROVED." Custom-made to your specifications.



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fering in impact strength. A third type had been under consideration for inclusion in the standard, but was eliminated to simplify the classification.

Polyvinyl chloride sheets are characterized by thermoplasticity, toughness, and excellent corrosion resistance. They are suitable for low temperature, low load applications. The Recommended Standard defines PVC sheet as rigid vinyl chloride polymer and/or copolymer resins and any necessary stabilizers and lubricants with or without addition of dyes, pigments and fillers.

The physical requirements for rigid polyvinyl chloride plastics sheets are as follows:

Type I (Normal impact)

| | |
|---|---|
| Tensile str | 7000 psi |
| Flexural str | 11,000 psi |
| Mod. of elasticity inflexure | 400,000 psi |
| Impact str Izod ft lb/in. notch | 0.5 |
| Heat distortion temp at 264 fiber stress | 158 F |

Type II (High impact)

| | |
|---|---|
| Tensile str | 5000 psi |
| Flexural str | 8500 psi |
| Mod. of elasticity in flexure | 300,000 psi |
| Impact str Izod ft lb/in. notch | 3.0 |
| Heat distortion | 150 F |
| Hardness Rockwell-R | 100 |

The standard also includes allowable changes in physical properties of sheet after immersion in various chemical reagents. Sampling methods, acceptance tests, and testing methods are also included in the standard.

## Plastics Armor Weighs Less

Lightweight armor plate recently approved by the Navy and Air Force makes possible the protection of larger areas on aircraft from damage by flak and small arms fire. The armor, a moldable,

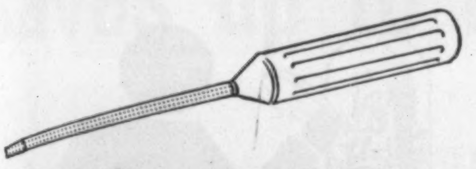
**TAYLOR**
**Laminated Plastics**
**Vulcanized Fibre**

# Shop Talk

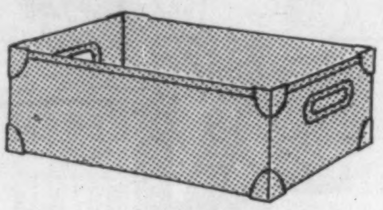
TAYLOR FIBRE CO.
*Plants in* Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • VULCANIZED FIBRE • POLYESTER GLASS ROD

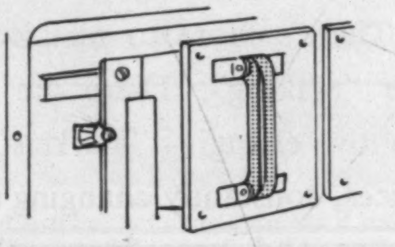
## Tips for designers



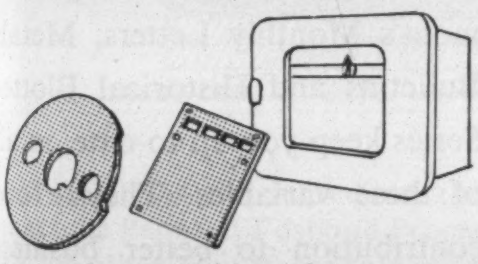
***Insulated fibre screw drivers,*** made of high dielectric strength Taylor Fibre, are electrically safe, physically tough.



***Tote boxes*** must withstand severe usage . . . an ideal application for tough, durable Taylor Vulcanized Fibre.



***Fuse box handle*** formed from Taylor G-5 Melamine Laminate has high electrical and mechanical strength . . . provides high resistance against corrosive fumes.



***Cam and terminal board*** for recording instrument is made of Taylor Grade XP Laminate . . . noted for its electrical insulating properties and ease of machining.

### TAYLOR FABRICATING FACILITIES

Your production can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and over-all costs reduced by having Taylor fabricate finished parts to your specifications. Efficient, modern facilities are ready to serve you. Get in touch with Taylor about your specific requirements.

Tip of 2″ diameter Taylor Built-Up Vulcanized Fibre Rod used as drift pin for driving out stuck roll-up shafts in paper mill. Heavy sledge hammer blows on end of rod could not split apart the laminations at bond joints.

## Taylor Built-Up Fibre withstands severest impact

The unretouched photograph above shows the strength and toughness of Taylor Built-Up Vulcanized Fibre. This is the tip of a 2″ diameter x 36″ long built-up fibre rod after more than a year's use as a crowbar and drift pin in a paper mill.

It was used as a bar to lift and pry 800 lb. objects. It was pounded with a 16 lb. sledge hammer in its use as a drift pin to drive out stuck roll-up shafts. Despite this severe and repeated abuse the rod was unbent. *And note that hundreds of sledge hammer blows have not severed the adhesive bonds between laminations.* Rather it is the fibre itself which has first failed. This is proof that built-up fibre is just as strong and as tough as homogeneous fibre.

Wherever exceptionally thick sections are required—for rods, plates, blocks—Built-Up Fibre can be produced in thicknesses up to 3 inches. Laminations are bonded together with specially developed adhesives to make a tough, solid mass.

For many applications, Taylor Built-Up Fibre can be used as a direct replacement for more expensive homogeneous commercial fibres. Moreover, it is available in a fraction of the delivery time. Outstanding physical and electrical properties make it the ideal material for heavy switchgear, arc barriers, insulating plates, rods, cutting blocks, bumper blocks . . . and a variety of similar uses.

Ask your Taylor representative about the numerous profitable applications for versatile Taylor Vulcanized Fibre and Taylor Laminates in your product. There are literally thousands of uses for economical, easy-to-form Taylor products.

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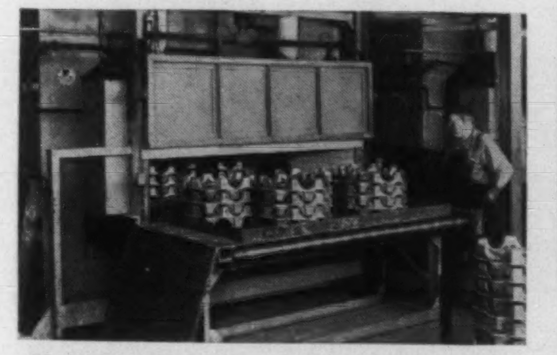
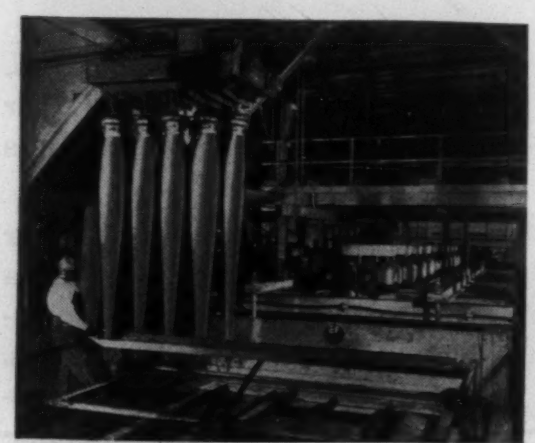
for
ALUMINUM AND
MAGNESIUM



EF Combination Gas-fired Radiant Tube and Electric Furnace for Heat Treating Alloy Crank Case Sections, Pistons, etc.

Our wide experience in homogenizing, solution treating, aging, billet heating, brazing, finish annealing and other processing of aluminum, magnesium and other non-ferrous and ferrous products can save you time and money. We build continuous and batch type furnaces,—gas-fired, oil-fired or electric . . . whichever is best for your particular requirement—furnished complete with all necessary charging, discharging, quenching, special atmosphere and special handling facilities. For long, efficient, trouble-free service, let EF engineers work with you on your next furnace problem.



EF Continuous Automatic Furnace for Solution Treatment of Forged Aluminum Propellers.

**BULLETIN No. 461**
**shows typical installations of EF Gas-fired, Oil-fired and Electric Furnaces**
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## News Digest

***Plastic armor plate*** *is examined after several .22-cal rifle shots were fired into it at point blank range.*

laminated reinforced plastic, offers considerable stopping power to projectiles due to its large energy absorption factor. The material weighs only one quarter as much as metal, and since it is easily molded in complex shapes, it offers decided production advantages. Too, the nonmagnetic character of the material makes it practical to armor plate radar and navigation instruments.

Tests conducted by the military and by researchers at Bassons Industries Corp. show that a .22 calibre rifle bullet fired point blank at a thin section of the material will not penetrate it, but instead, raises a blister-like delaminated area around the point of impact.

### New Weld Reduces Bead

Welded tube and pipe manufacturers have always had trouble with the weld bead on the inside diameter of welded tubing. A rather simple change in the welding process, instituted by Trent Tube Co., has reduced the interior bead significantly, and in some cases has eliminated it entirely. Without an interior bead, the tubing has better physical properties, improved corrosion resistance, and greater formability.

**Inverted weld seam**

Trent's solution to the interior bead problem reverses a basic

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and the Figures
ask Belmont!

There's more to metals than the "making". There are constantly changing markets and prices, constantly changing techniques and procedures—all of which function in intelligent metals buying and selling. Belmont's Monthly Letters, Metals Bulletins and Historical Blotter Series keep you up-to-date on all of these variables. They're our contribution to better business through better information. They're yours for the asking.

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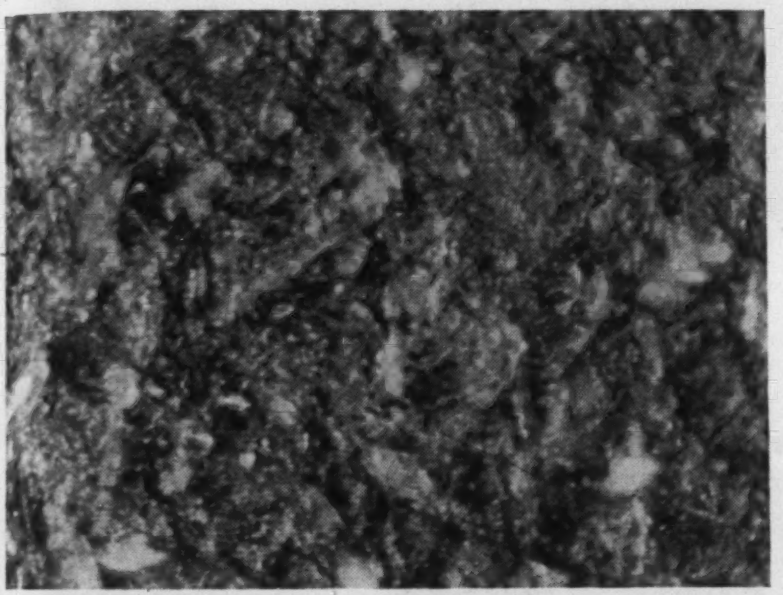
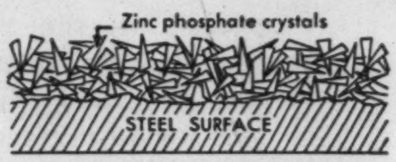
# Sensational new Actidip

## prevents loose, powdery phosphate coating, saves up to half your costs

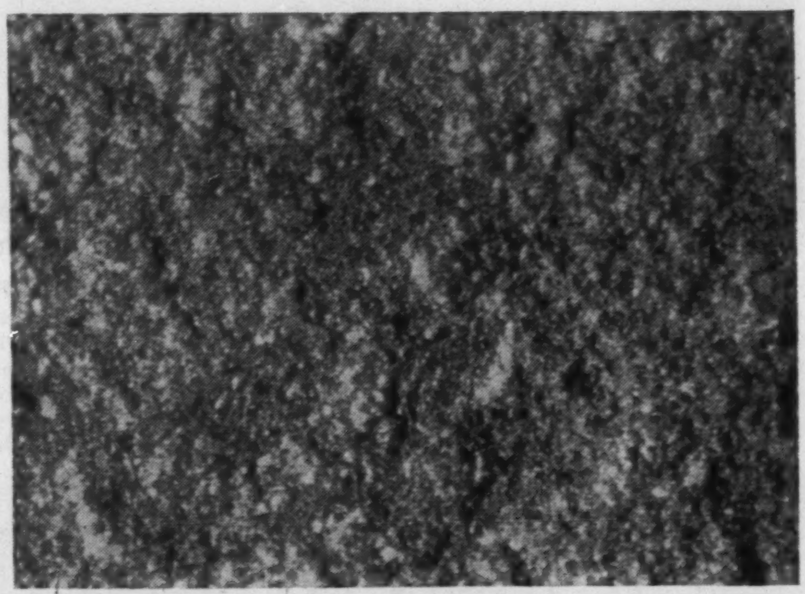
UNRETOUCHED PHOTOMICROGRAPHS (enlarged 75 times)



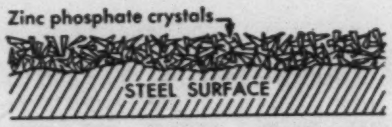
**Without Actidip,** this panel received a conventional phosphate coating. Typical large crystals, uncontrolled deposition, "wide open spaces" mean heavier coating needed for real protection, more paint needed to cover.



**LARGE CRYSTALS on non-activated surface**



**With Actidip and the Fosbond Process,** this panel shows the controlled crystal size and dense packing which lead to a lighter zinc phosphate coating and greatly reduced paint consumption.



**SMALL, DENSE CRYSTALS on Actidip-activated surface**

ACTIDIP® is the ingredient that makes the Pennsalt Fosbond Process like no other zinc phosphate treatment you've ever seen.

By activating the surface of ferrous or zinc parts to receive an optimum phosphate coating, Actidip works to:

- shorten the processing time in the Fosbond bath;
- reduce the size of Fosbond crystals;
- crowd them evenly and thinly over the metal surface;
- retard formation of sludge in the Fosbond solution.

Even highly-polished, severely-worked, heat-treated steels (usually toughest to phosphatize) are coated successfully — consistently — when Actidip paves the way. *And costs using a Pennsalt Cleaner containing Actidip are about one-fifth the cost of emulsion cleaning.*

**THE PAY-OFF IN YOUR PROCESS:** (1) Vastly improved corrosion-resistance under organic finishes; (2) reduction in the consumption of phosphatizing chemicals by up to 40%, and of paint by as much as two-thirds; (3) better adhesion and gloss-retention even in one-coat paint systems. Also activated cleaners are balanced so that they don't contaminate the phosphating bath.

**Activate with Actidip . . . phosphatize with Fosbond®**—you'll get uniform high quality in paint-bond coatings while actually cutting 'way down on processing costs. Call your Pennsalt service man for a demonstration of Actidip and Fosbond *in your equipment.* Or write to Customer Service Department, Pennsylvania Salt Manufacturing Company, Three Penn Center Plaza, Philadelphia 2, Pa.

**See us at Booth 1272—Metal Show—Phila.**

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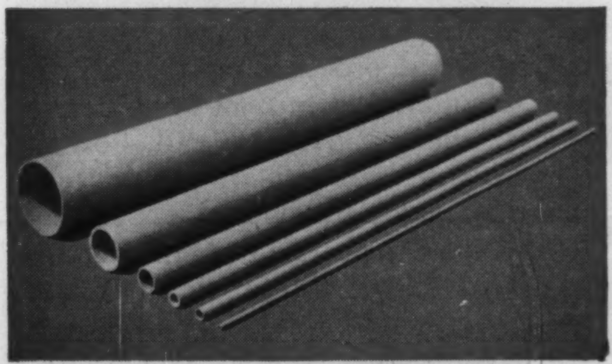

• McDanel High Temperature Ceramic Tubes are guaranteed up to 2,900° F. Some are so small (only a few thousand O.D.) that only finest gauge thermocouple wires can be inserted. Others range up to 9" O.D. for heat treating furnaces. All McDanel Ceramic Tubes have a high resistance to thermal shock and low coefficient of expansion. They're guaranteed gas-tight. Uniform performance is assured by continuous, exacting control. Special sizes, large or small, can be made. Write us now.

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McDANEL Industrial PORCELAINS
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practice in roll formed tube welding—the tube is formed so that the seam is on the underside of the pipe as it leaves the rolls, and the weld is accomplished with the electrode positioned beneath the weld. The seam is joined by a standard butt weld using the inert-gas-shielded tungsten arc process. Because the weld is performed upside down, the metal does not flow into an interior bead.

**Properties**

The new welding system, in addition to controlling the interior bead, results in many improvements in tubing and pipe from both metallurgical and mechanical aspects, according to Trent Tube. There is a notable absence of grooves, valleys, or undercuts in the weld area after cold working or drawing. The outside diameter weld bead can be held uniform and smooth so that it is possible to reduce it by swaging and improve its mechanical properties without undesirable side effects.

Heavy wall tubing and pipe will meet all mechanical tests such as flare, transverse, tensile and reverse bend. The tubing and pipe are said to have better fabrication properties in the production of tube assemblies, heat exchangers, condensers and boilers. The smooth inside surface offers better conditions for rolling in tubes in tube sheets. Many of the high alloys or super alloys that previously required welding can now be rolled into tube sheets.

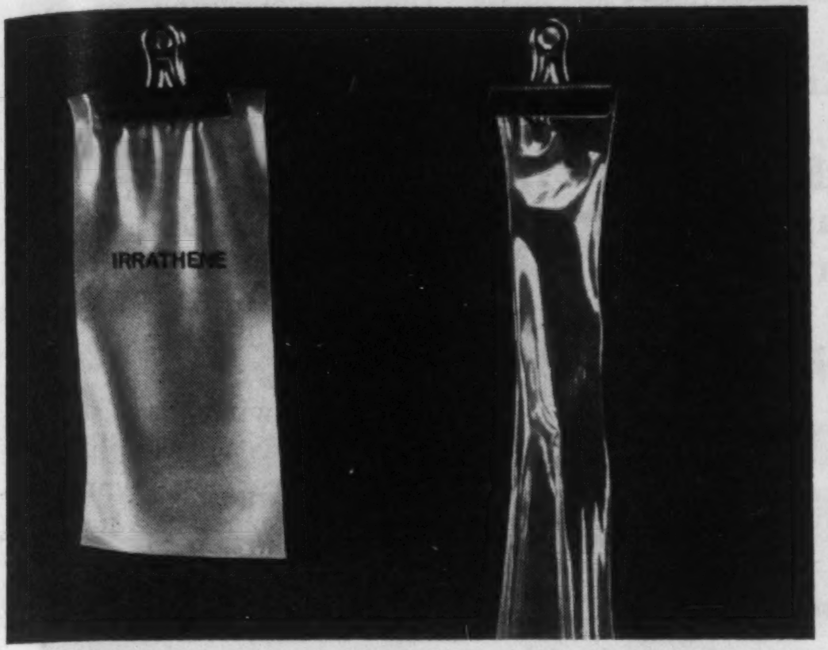
Corrosion resistance has been improved because the absence of valleys or grooves, simulating an undercut condition, leaves no place for solids to deposit or corrodants to become entrapped, thereby eliminating possible failure due to pit type corrosion.

The production of cold drawn tubing for aircraft hydraulic lines, pneumatic systems and tubing for small heat exchangers requires a starting stock of the highest quality. Tubing welded by the new "inverted" method appears to meet all such requirements. The smooth joints minimize the possibility of fatigue

## WHERE CAN YOU USE THIS

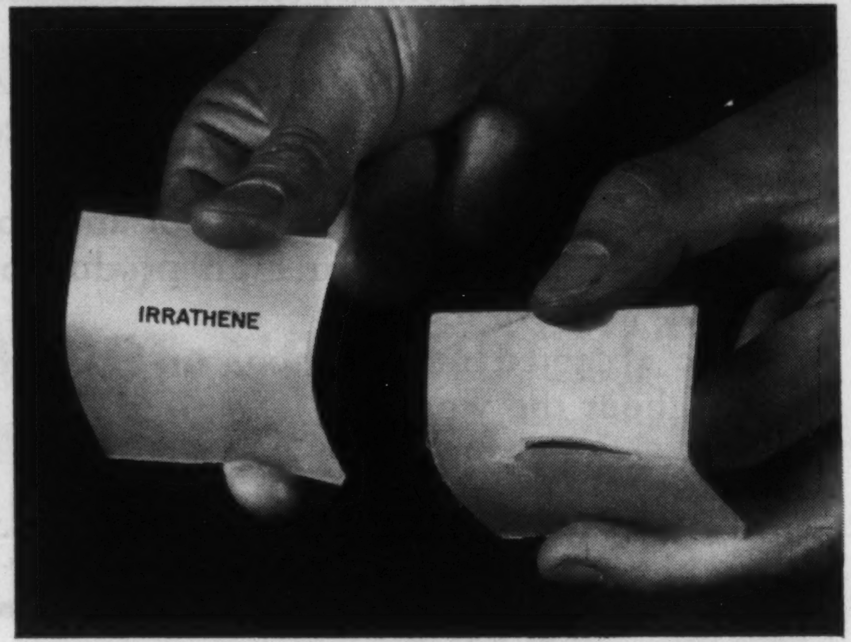
# NEW PLASTIC MATERIAL*

## WITH THESE PROPERTIES?



**WITHSTANDS TEMPERATURES AS HIGH AS 200°C . . .**

. . . for limited time; continuous temperature limits range from 105°C to 125°C. The two sheets of film above were exposed to temperatures of 150°C for 5 minutes; the G-E Irrathene *irradiated* polyethylene film on the left does not melt, while the ordinary polyethylene on the right has melted and flowed to twice its original length.

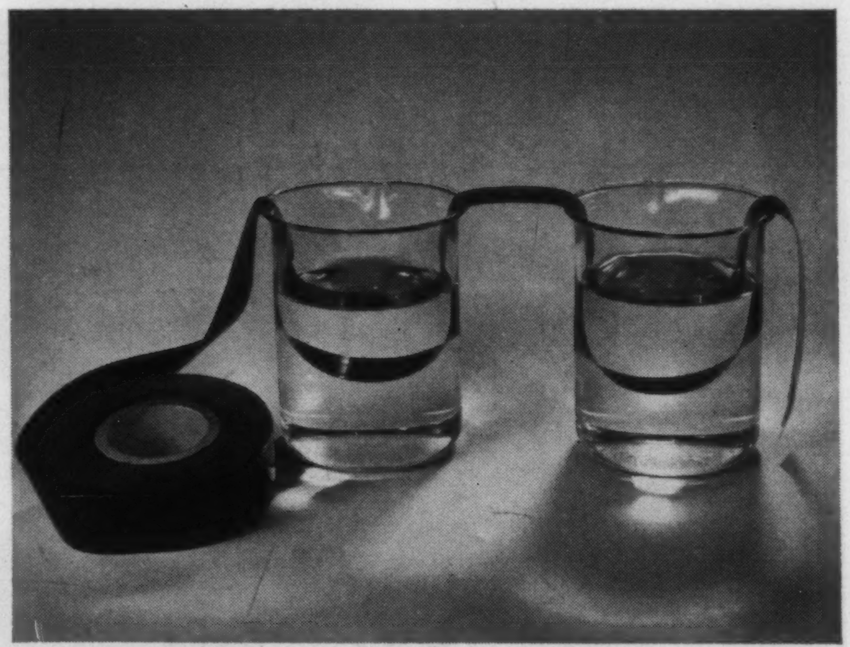


**RESISTS STRESS CRACKING**

The G-E irradiation process eliminates environmental stress cracking—an important problem in polyethylene cable, for example. Here two .125″ pieces were bent sharply in a detergent solution to induce environmental stress cracking. Ordinary polyethylene (right) fails completely, whereas Irrathene has not even begun to craze.

**SHRINKABLE GRADES FOR ENCAPSULATION**

G-E Irrathene tape, grade 210, can be wound on irregular shapes such as electrical coils, pipe fittings, etc., then heated and shrunk around the object and over the ends to provide a tight, form-fitting, thermally sealed encapsulating layer.



**MOISTURE AND CHEMICAL RESISTANCE**

Irrathene tape and film is virtually impervious to moisture, including direct immersion. And, being chemically inert, it successfully resists most ordinary chemicals.

* IRRATHENE
IRRADIATED
POLYETHYLENE

*Along with the special properties described above, G-E Irrathene irradiated polyethylene also retains all the outstanding properties of regular polyethylene, including excellent dielectric characteristics. To help you apply G-E Irrathene in your product or process, we have prepared a special technical report; why not write today for your copy and an evaluation sample to: Sect. 1504-C. Chemical & Metallurgical Division, General Electric Company, Pittsfield, Mass.*

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

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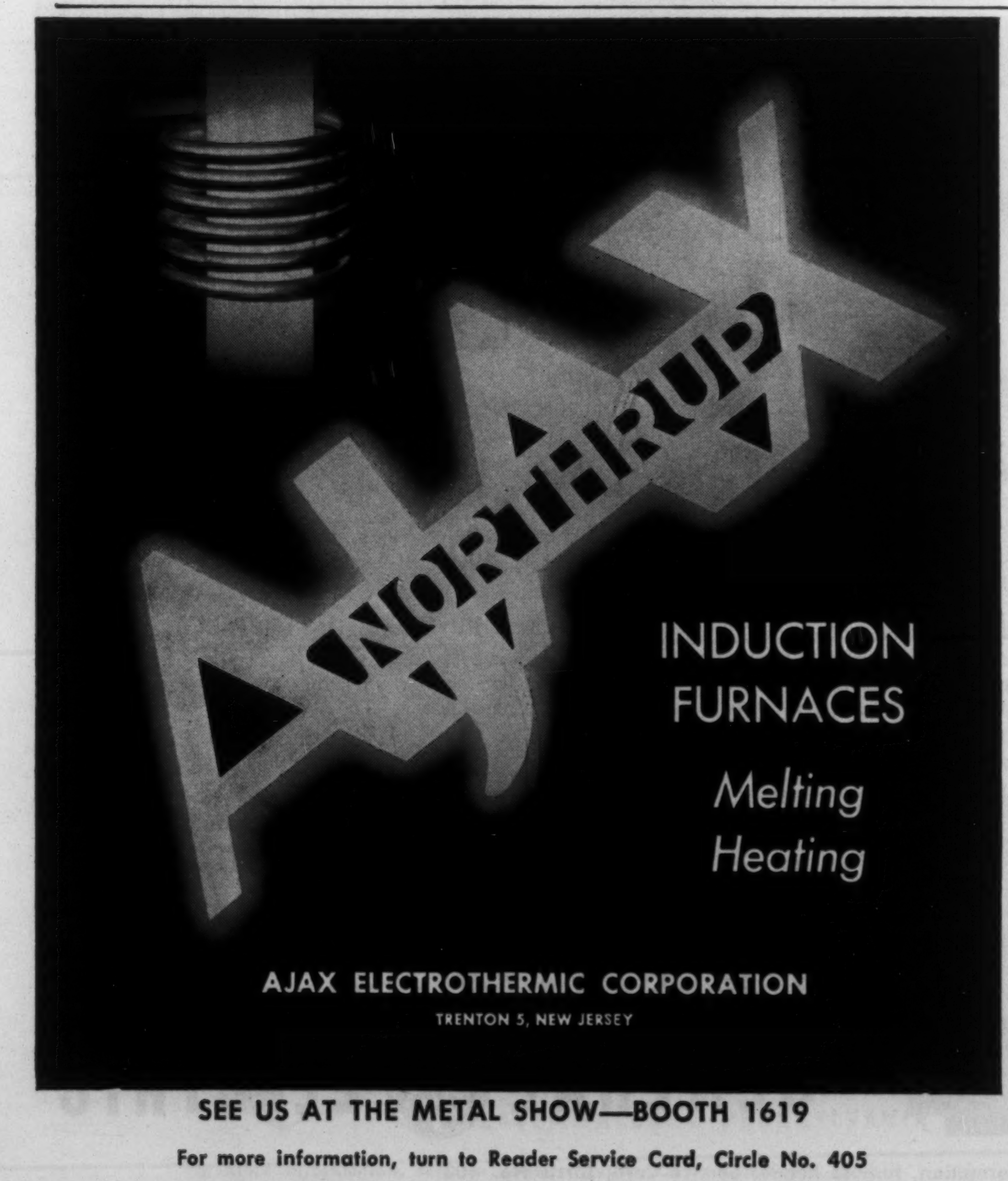
Ajax Electric Company, Inc. The Ajax-Hultgren Electric Salt Bath Furnace
Ajax Engineering Corporation, Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces



SEE US AT THE METAL SHOW—BOOTH 1619

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failure and make better joints with flare type fittings used in the aircraft industry.

**Materials**

The new welding process is said to lead to the use of several alloys that have not previously been furnished in welded tubing, and further, permits cold drawing of these alloys into extremely thin walled tube. Various Hastelloy grades, zirconium, Zircoloy, titanium, and 19-9-DL are all available in fully finished grades.

The welded tubing is suitable for the following five services: corrosion resistant applications; heat resistance; low temperature service; high pressure pipe; and architectural and mechanical applications. The welded pipe and tubing is supplied in all AISI stainless, special high alloy grades, such as Hastelloy, and in titanium and zirconium alloys.

## Control Growth of Uranium Rods

One of the most important problems of nuclear reactor technology—preventing uranium from changing size during operation—has been solved. Scientists at Argonne National Laboratory and at other Atomic Energy Commission laboratories have found that heat treatment and rolling temperatures used on uranium fuel elements can control unwanted growth or shrinkage in fuel elements.

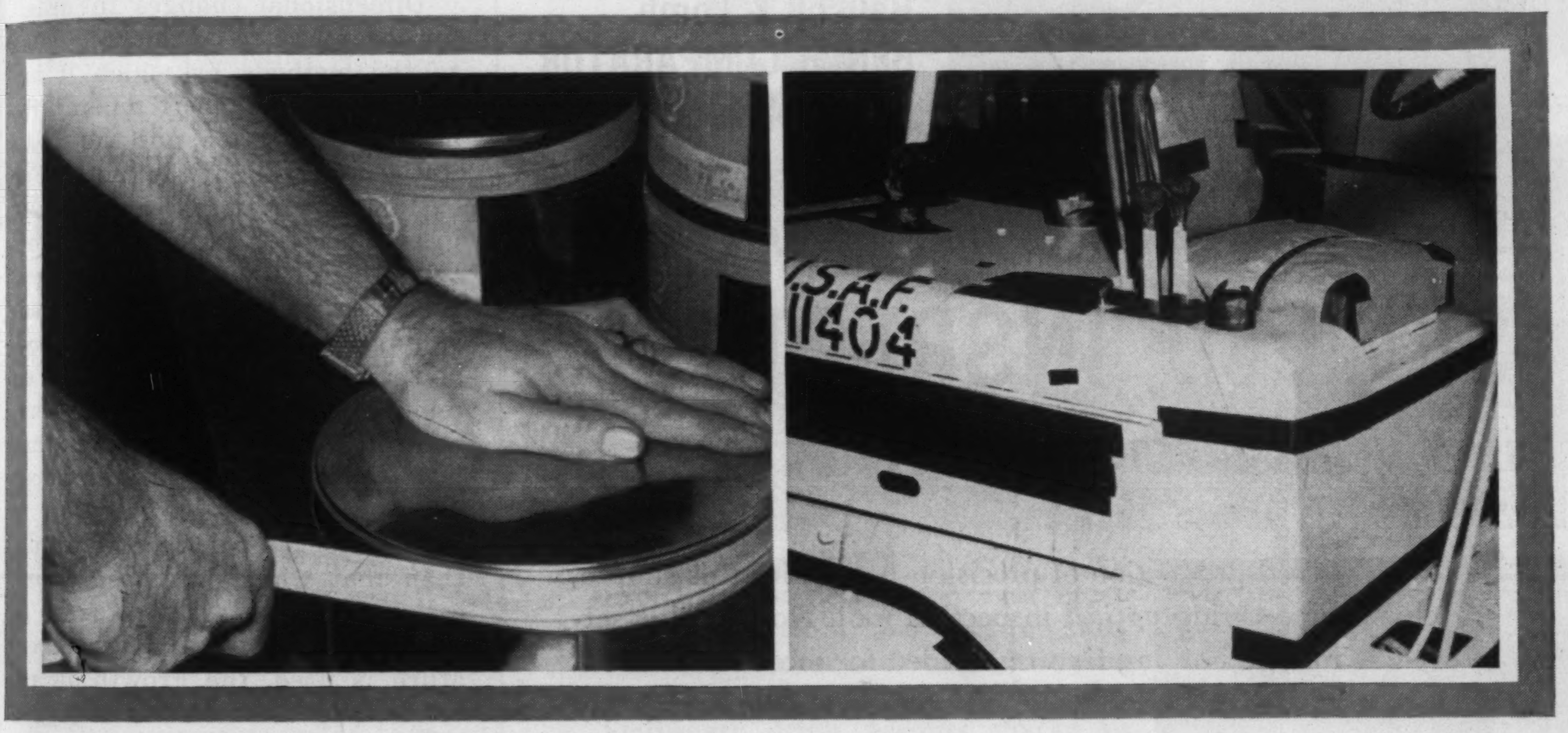
Argonne metallurgists, S. H. Paine and J. H. Kittel, in a paper prepared for the United Nations' International Conference on the Peaceful Uses of Atomic Energy, indicate that the stability of uranium fuel is perhaps the most important practical problem in the operation of nuclear reactors. The authors of the paper entitled "Irradiation Effects in Uranium and its Alloys" report that it is most important that the shape and size of the reactor core remain unchanged after a period of operation.

Experience has shown that fuel elements made of uranium lose their shape badly under nuclear

# Polyken TAPES

CONTROLLED STRENGTH

## KEEP PRINTING INKS MOIST, LIFT TRUCKS DRY



Here you see *Polyken* Tape being used in two different applications—each requiring a dependable, low-cost moisture barrier.

The cans of printing ink at the left are sealed to prevent the ink from drying out. The tape also protects the contents from dust and keeps the tops secure during rough handling and shipping. The durable cloth-backing of *Polyken* permits repeated use of the tape.

The lift trucks in the other picture—scheduled for overseas shipment—have a waterproof seal of *Polyken* Tape for protection against salt water damage.

In both cases, the ease of applying *Polyken* Tape right from the roll saves many man-hours. And because *Polyken* Tape *stays put*, less is needed for an efficient seal.

These cost-cutting advantages result from *Polyken controlled strength*—the right combination of backing and adhesive to do the best possible job *with the least possible tape.*

Whether your need involves sealing; protection in storage and shipment; wrapping and packaging; or a special requirement—you can depend on Polyken *Controlled Strength* Tapes.

Get complete information by sending the coupon.

**Polyken®**

**INDUSTRIAL TAPES**

**Polyken Products Department of The Kendall Company**

**Polyken, Dept. MM-J**
**222 West Adams St., Chicago 6, Illinois**

Please send me physical properties and further information on *Polyken* Controlled Strength Tapes.

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Company________________________________

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BENCH COMPARATOR
$765

*So easy, inexperienced help become*
**SKILLED INSPECTORS**
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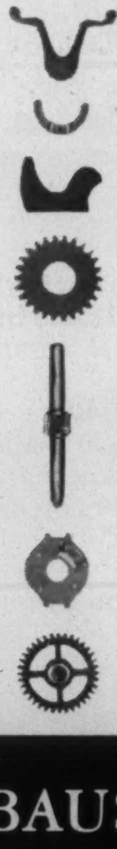

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**INSTRUMENTS**

bombardment and even under repeated temperature cycles. For example, under some conditions, rods of uranium have been known to more than double their length after a burnup of only one atom in each thousand.

At Argonne National Laboratory and at other U.S. Atomic Energy Commission installations, metallurgists have succeeded in isolating the basic causes of this instability and have learned how to treat the metal so that it is stable under irradiation.

Dimensional changes in uranium are found to be closely related to the methods by which it has been fabricated, the temperatures used in fabrication, and the chemical composition of the metal. For example, castings elongate or grow much less rapidly than most types of rolled uranium. However, rolling of metal has certain advantages as a fabrication method, and it is here that dependence on temperature is most clearly demonstrated. Uranium which has been rolled at temperatures about 300 C (572 F) has been found to grow in length much more rapidly than that which has been fabricated at higher temperatures. In fact, if a high enough temperature is used, the growth is reversed and the metal is observed to shorten under irradiation.

Normal impurities in uranium do not radically affect its radiation behavior, but additions of certain alloying elements such as silicon, chromium, zirconium, niobium, or molybdenum, can be beneficial. Unalloyed uranium develops a rough surface even when it has been made dimensionally stable. This effect is caused by the large size of the crystals or "grains" which make up the metal. Addition of the alloying elements mentioned above reduces the grain size in the metal, thus improving the surface smoothness.

As a result of such studies a number of methods have been found for conserving the dimensions of uranium under irradiation.

Where design will permit simple shapes, alloy castings are highly satisfactory. Where rolled shapes must be used, proper rolling temperature or subsequent heat treatment has been found effective.

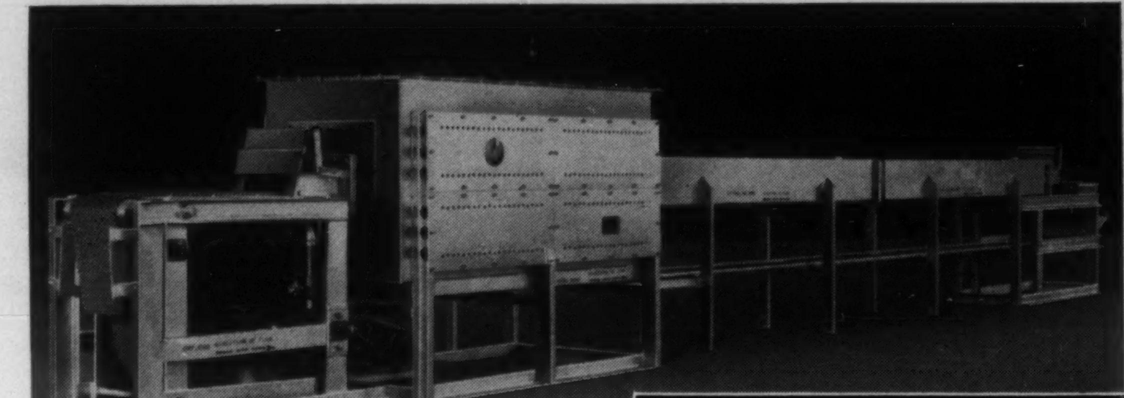
### River Water Exposure Coating Test Results

A coating system designated as an "aluminum pigmented vinyl paint system" has recently been judged one of the best of 25 systems, consisting of eight vinyl systems, fourteen phenolic varnish-pigment paints and three rubber base and coal tar coatings. The ratings were established from the standpoint of corrosion-resistance in a continuing test conducted by the Corps of Engineers, U.S. Army, Pittsburgh District. The system comprises a primer coat of Vinsynite and three coats of aluminum-pigmented vinyl.

The test was initiated in Sept. 1949, at which time the Vinsynite-Vinyl system and twenty-four other systems of coatings were applied to twenty-five sections of the steel-plate life gate of the Ensworth Dam, Ohio River, near Pittsburgh, Pa. Purpose of the test is to gather data relative to the comparative abilities of the various coatings to resist corrosion over long periods of time. Each test section is approximately four feet by twelve feet.

Coatings were applied to the upstream side of the flood gate, which is submerged approximately one foot below the surface of the river at all times except during flood conditions and when repairs are being made. The gate had been painted in 1943 after wire brushing, and in 1949 when test coatings were applied, some of the old paint remained and some areas were pitted with a considerable amount of rust. Rust and old paint were removed by wire brush, scraper and paint remover. However, a sandblast surface was desired by most participants in the tests. Primers and paints were then applied by brush and spray to the twenty-five test panels and the gate was permitted to dry for five days before submersion.

Rating of the panels was made



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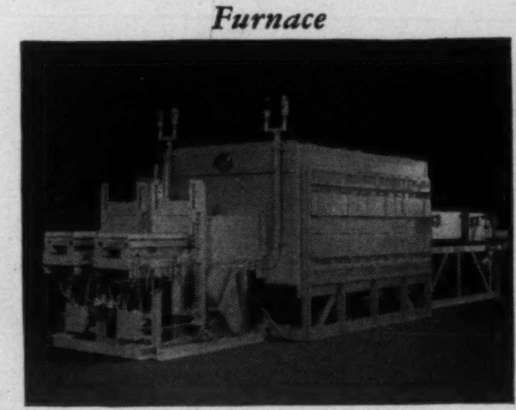
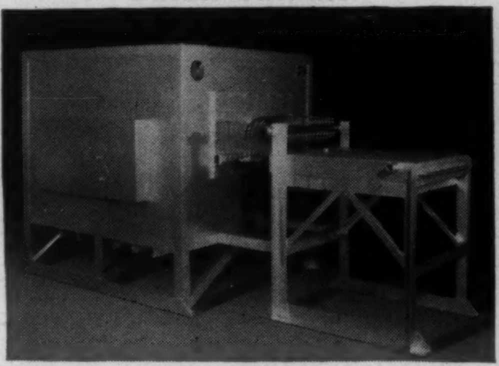


Harper Twin Muffle Pusher Furnace



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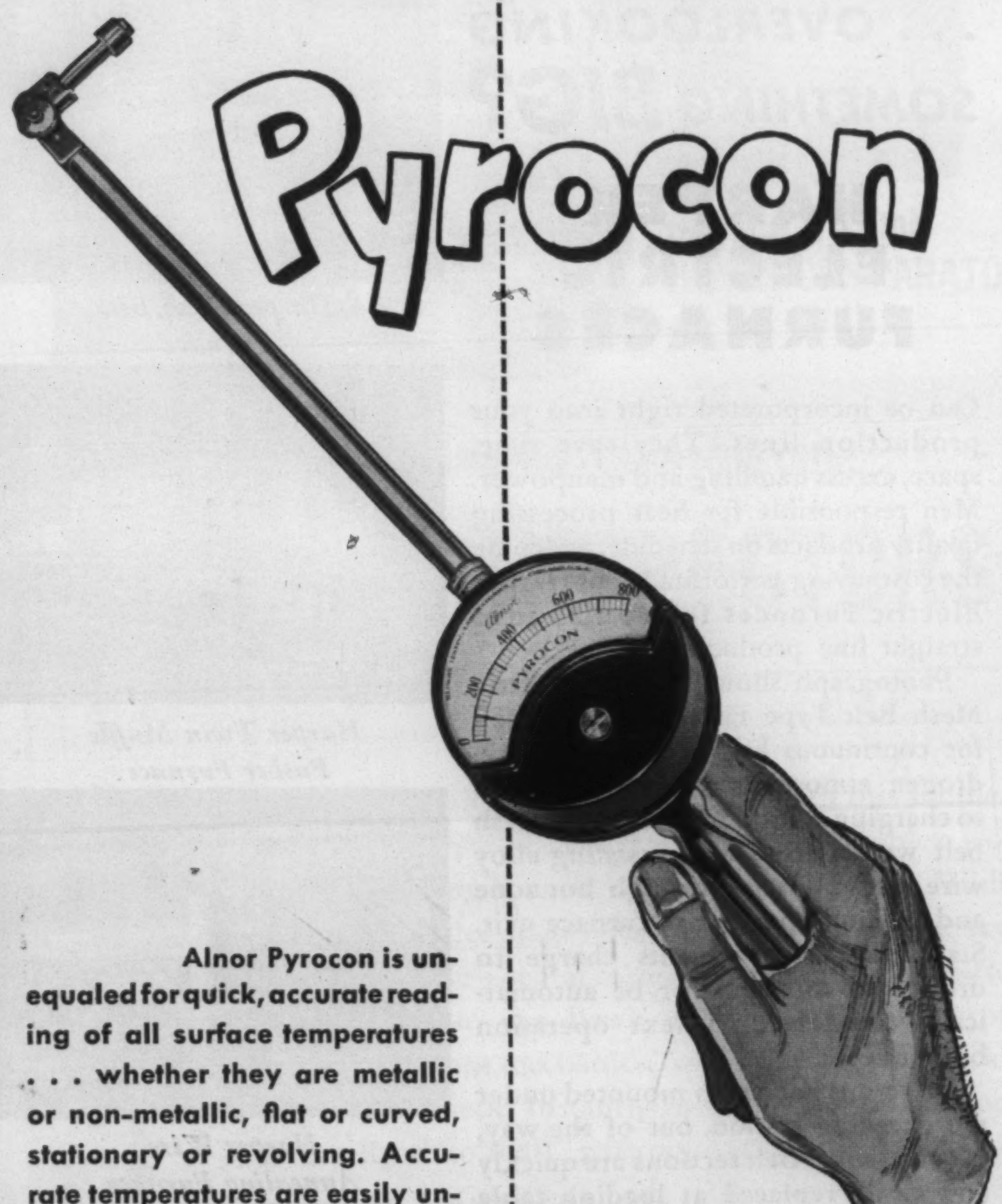

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by a point score method based upon a score of ten points for a perfect specimen, with four factors — rusting, blistering, top coats and primers — being considered.

The panels had been inspected and judged twice previously, in 1950 and 1952. At the first inspection the Vinsynite-Vinyl system had been tied for third place. At the next inspection, in Oct. 1952 it was judged first.

In the most recent inspection judging was done by a group of seventeen observers, twelve from industrial concerns and five from the Corps of Engineers. The industrial representatives again judged the Thompson system first of the twenty-five systems under test, after all systems had been subjected to approximately five years nearly constant submersion in river water.

The first place Vinsynite-Vinyl system consists of a primer coat of FS-2 Vinsynite, and improved wash-primer type of coating followed by three coats of Thompson aluminum-pigmented vinyl paint. Application of both materials was by brush, with twenty-four hours drying time between coats. Total thickness of the four coats was 6 mils. The primer and paint is manufactured by Thompson & Co., Oakmont, Pa.

Vinsynite is widely-used both for maintenance and for metal products finishing. In addition to type FS-2 for ferrous metals, there is a type AU-1, formulated for use on any non-ferrous metals. Both types act as improved wash primers, achieving superior corrosion-resistance and at the same time maximum adhesion for topcoats of paint. All types of finish coats are up-graded through the use of Vinsynite, with specific finish coats being selected according to performance requirements.

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